Animal physiology, particularly vertebrate physiology, focuses on the interactions and functions of the different body systems.

Organization of Animal Bodies

All animal cells share similarities in the ways in which they

- Exchange materials with their surroundings
- Obtain energy from organic nutrients
- Synthesize complex molecules
- Reproduce themselves
- Detect and respond to signals in their immediate environment

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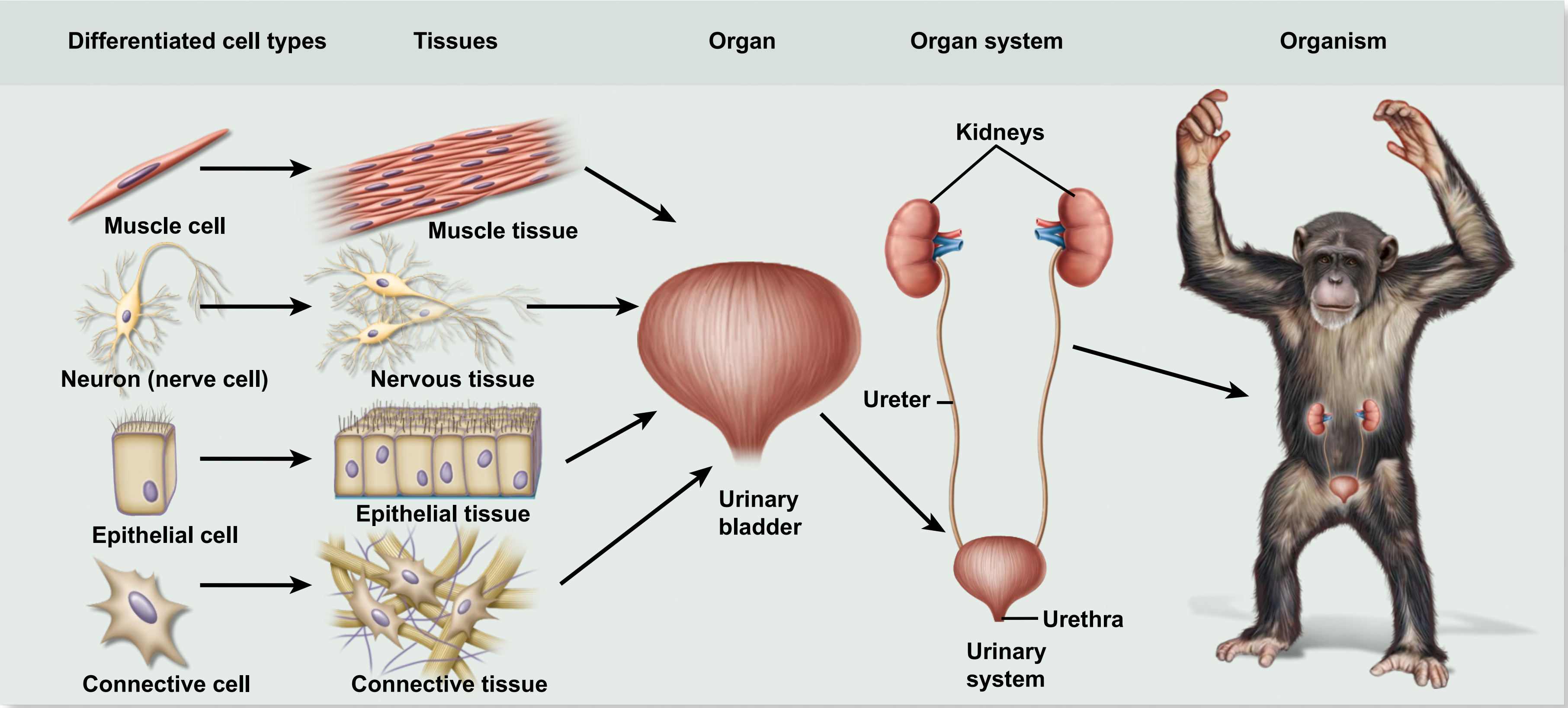
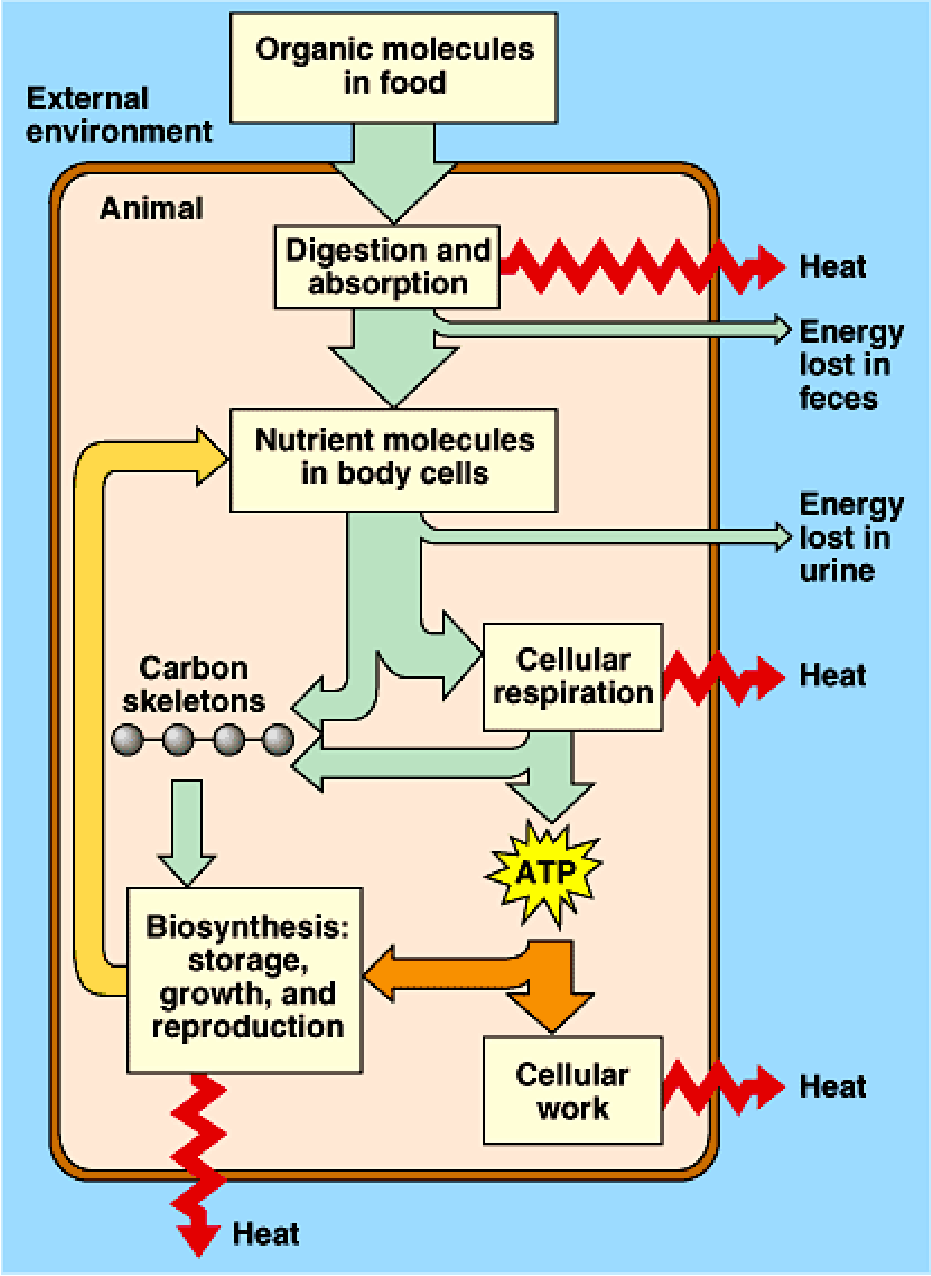


Cells with similar properties group to form **tissues**

Tissues combine together to form **organs**

Organs are linked to form **organ systems**

BIOENERGETICS OF AN ANIMAL: AN OVERVIEW



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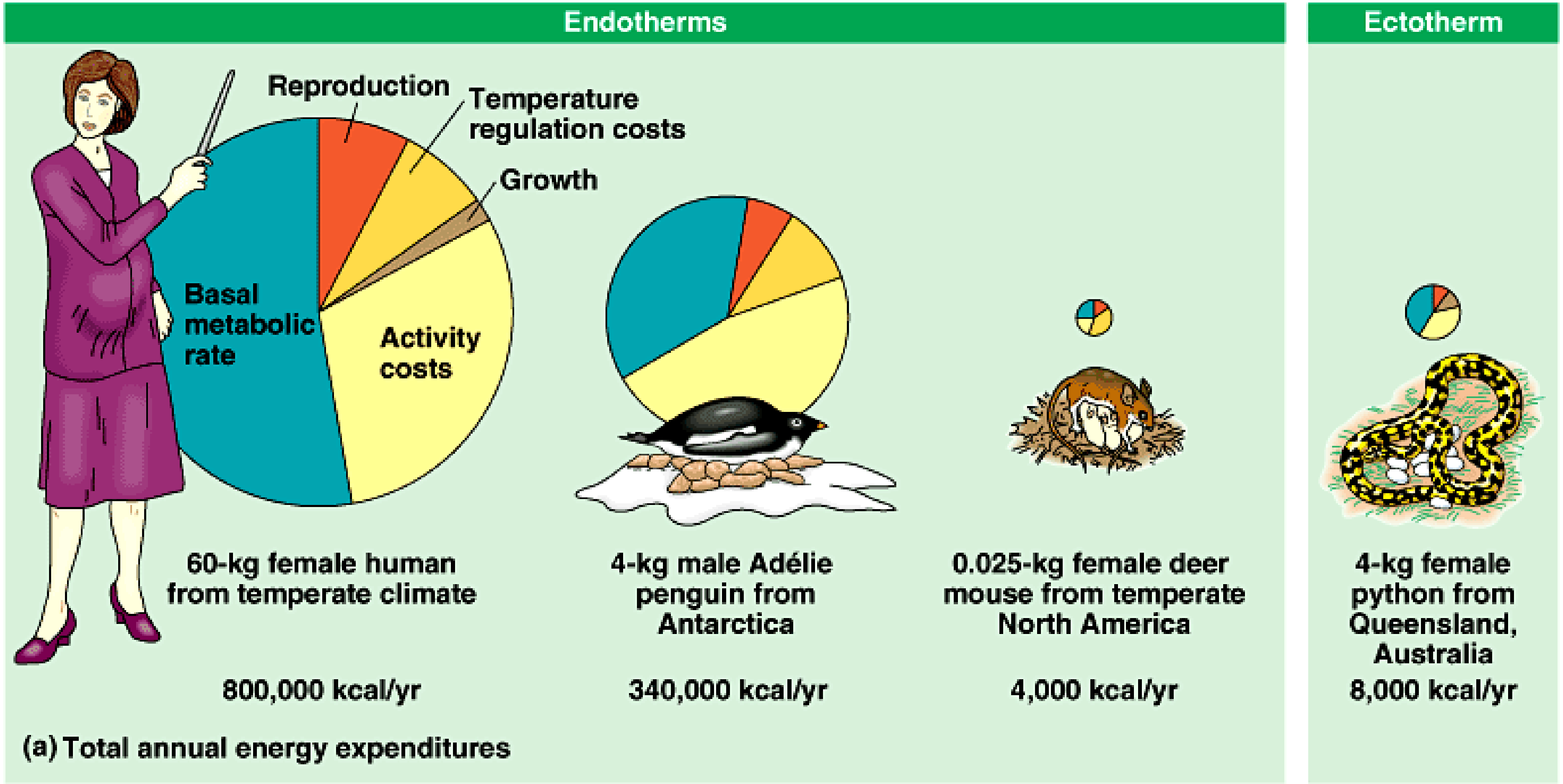
ANNUAL ENERGY BUDGETS FOR FOUR ANIMALS: TOTAL ANNUAL ENERGY EXPENDITURES 40.2



(a) Total annual energy expenditures

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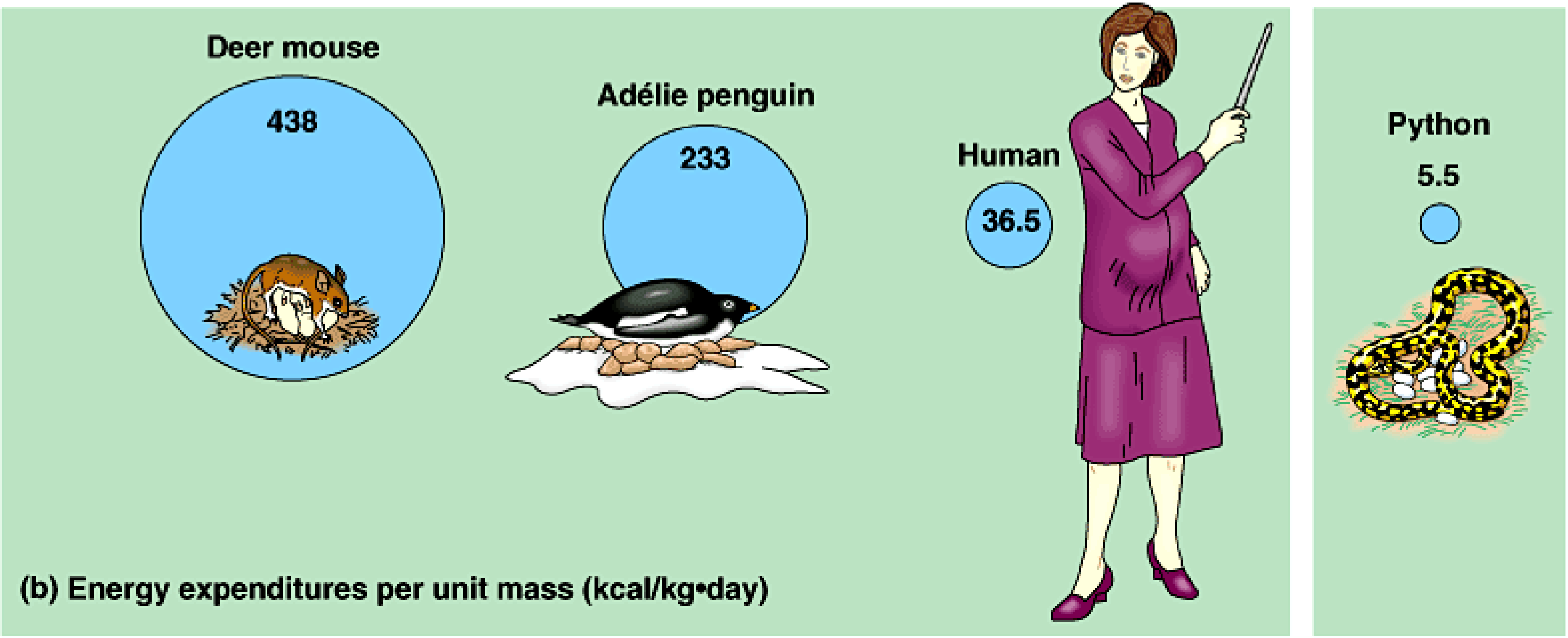
ANNUAL ENERGY BUDGETS FOR FOUR ANIMALS: ENERGY EXPENDITURE PER UNIT MASS



(b) Energy expenditures per unit mass (kcal/kg•day)

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FIGURE 33.4

Species		
Mass	35 g	4,500,000 g
Metabolic rate	890 mm^3 0_2/g body mass/hr	75 mm^3 0_2/g body mass/hr

The mouse has a much higher metabolic rate than the elephant. (credit “mouse”: modification of work by Magnus Kjaergaard; credit “elephant”: modification of work by “TheLizardQueen”/Flickr)

HOMEOSTASIS

Basic intro to human homeostasis

CTV

Homeostasis basics

Homeostasis

Def.: Process of maintaining a relatively stable internal environment despite changes in external surroundings

Some animals are **conformers**

- Maintain same composition as environment
- Requires less energy

Others are **regulators**

- Work to maintain body different than environment
- Requires more energy

Animal can be both with respect to different variables

No physiological function is constant for very long, which is why we call them **“variables”**

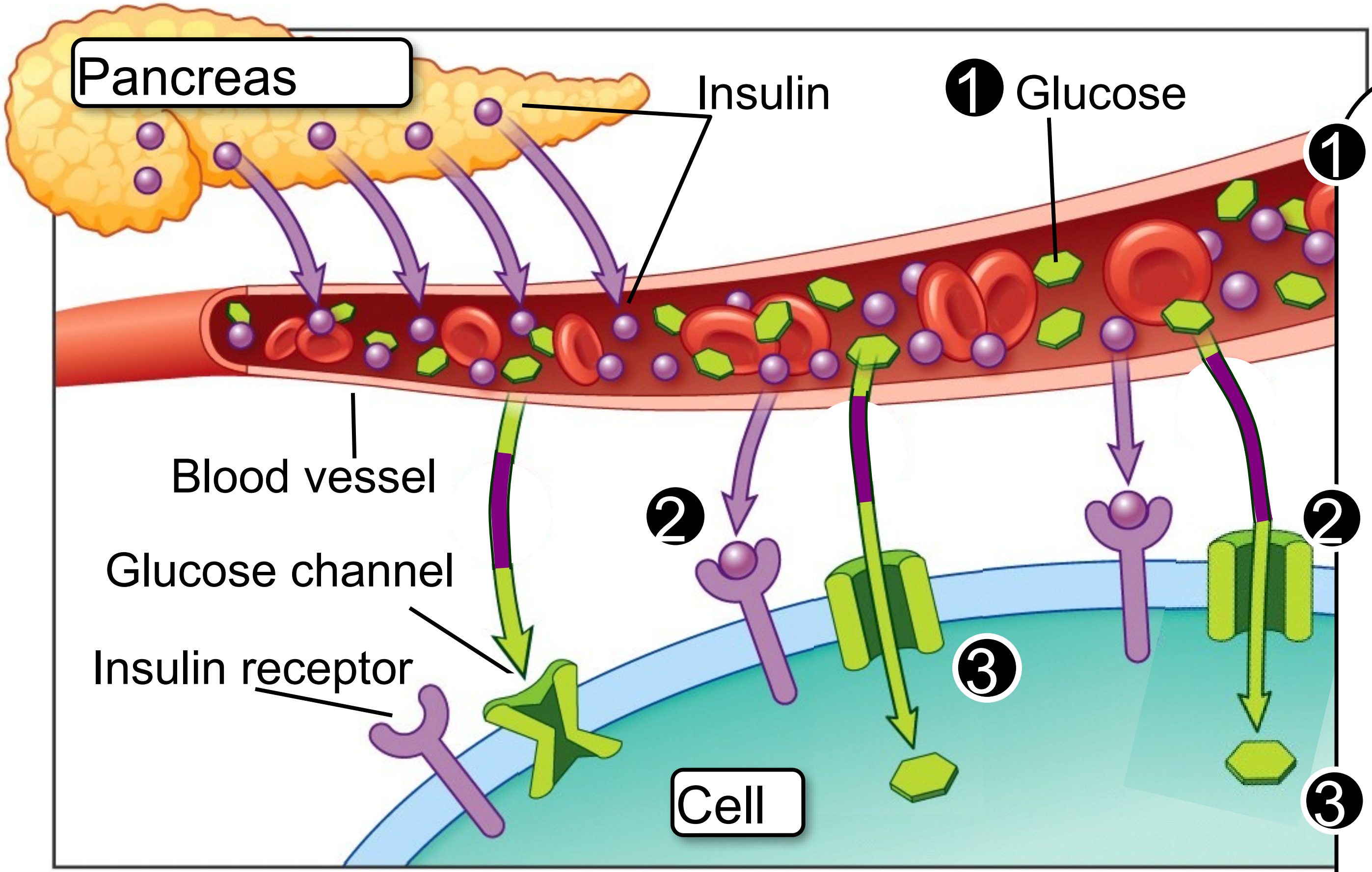
ex: Normally, **blood sugar** (glucose) remains at fairly steady and predictable levels in any healthy individual

After a meal the level of glucose in your blood can increase quickly

If you skip a meal, your blood sugar level may drop slightly

Homeostatic mechanisms restore blood glucose to normal levels in the blood

What happens to sugars in my bloodstream?



❶ Sugars in the bloodstream cause the pancreas to release insulin.

❷ Insulin binds to insulin receptors on target cells.

❸ This causes glucose channels to open & let glucose in.

Animation

Glucose homeostasis

fructose, are absorbed by the cells lining the intestine. Glucose passes out of the cells and into the interstitial fluid,

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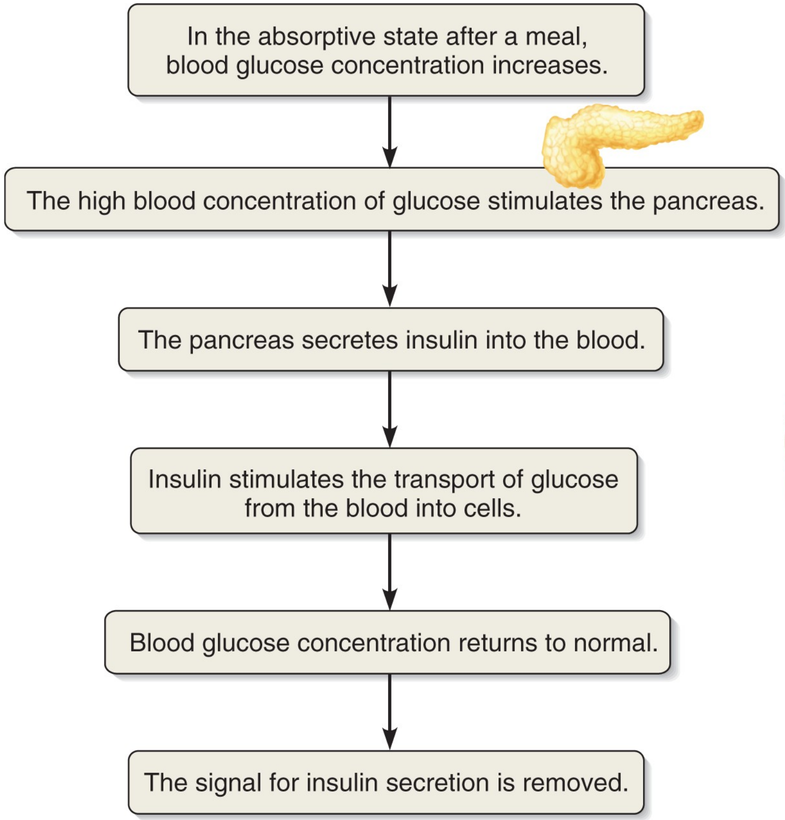


In the absorptive state after a meal, blood glucose concentration increases.

The high blood concentration of glucose stimulates the pancreas.

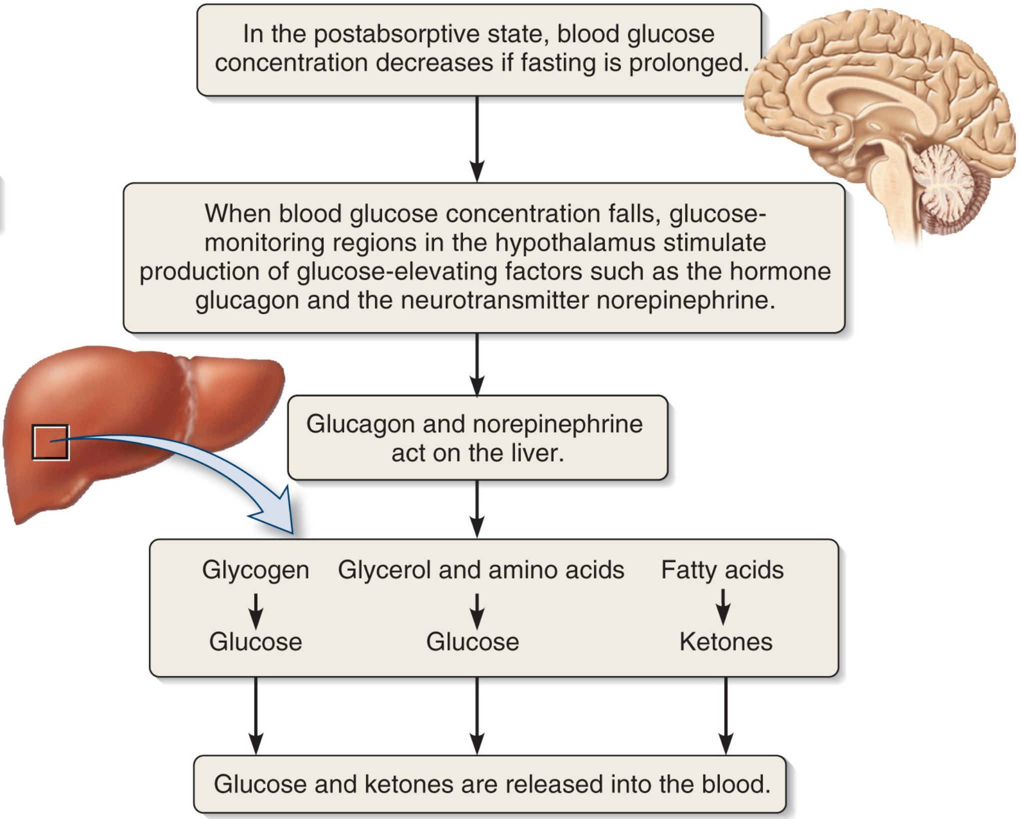
The pancreas secretes insulin into the blood.

Insulin stimulates the transport of glucose from the blood into cells.

Blood glucose concentration returns to normal.

The signal for insulin secretion is removed.

(a) When blood glucose concentration is high



In the postabsorptive state, blood glucose concentration decreases if fasting is prolonged.

When blood glucose concentration falls, glucose-monitoring regions in the hypothalamus stimulate production of glucose-elevating factors such as the hormone glucagon and the neurotransmitter norepinephrine.

Glucagon and norepinephrine act on the liver.

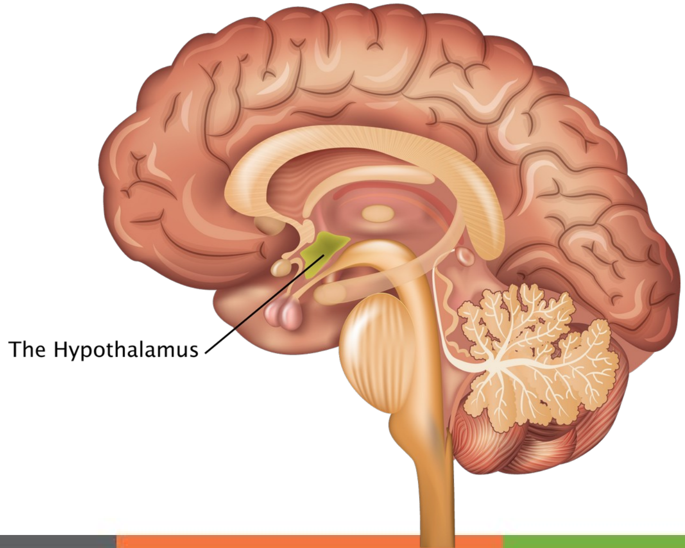
Glycogen	Glycerol and amino acids	Fatty acids
↓	↓	↓
Glucose	Glucose	Ketones

Glucose and ketones are released into the blood.

(b) When blood glucose concentration is low

NEGATIVE FEEDBACK

- Variable being regulated brings about responses that move the variable in the opposite direction
- E.g. Decrease in body temperature leads to responses that increase body temperature; increase is blood sugar levels leads to responses that decrease sugar in the blood.
- May occur at organ, cellular or molecular level
- Also prevents homeostatic responses from overcompensating



The HYPOTHALAMUS acts as the connector between the endocrine and nervous systems to achievehomeostasis. It plays a part in many essential functions of the body such as:

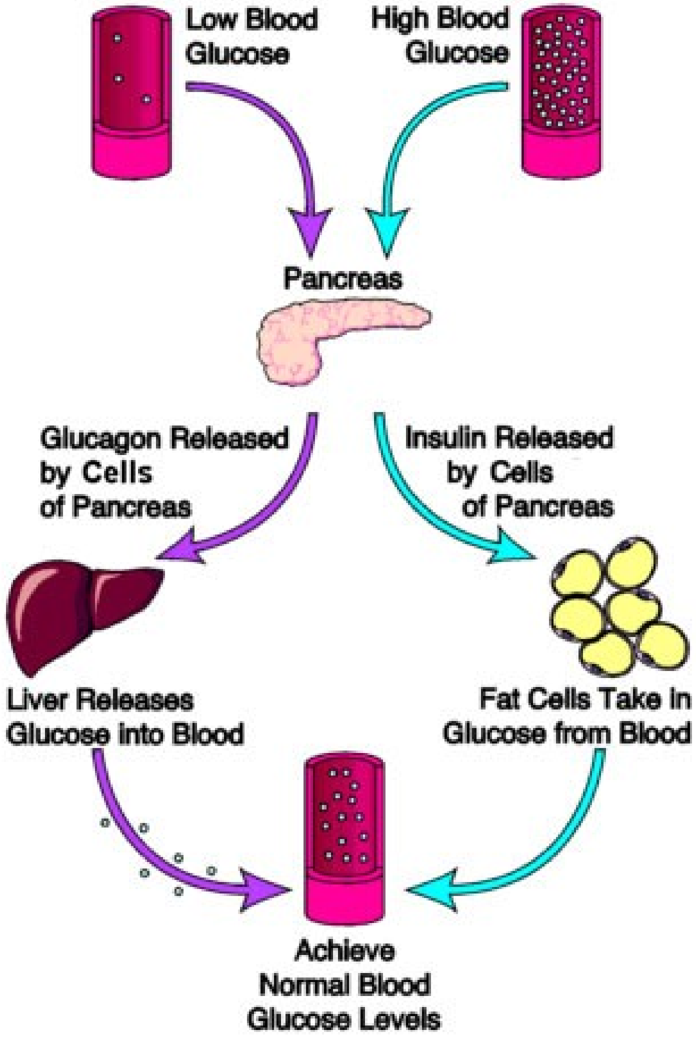
- body temperature
- thirst
- appetite and weight control
- emotions
- sleep cycles
- sex drive
- childbirth
- blood pressure and heart rate
- production of digestive juices
- balancing bodily fluids

As different systems and parts of the body send signals to the brain, they alert the hypothalamus to any unbalanced factors that need addressing. The hypothalamus then responds by releasing the right hormones into the bloodstream to balance the body.

https://www.medicalnewstoday.com/articles/312628#hormones-of-the-hypothalamus

NEGATIVE FEEDBACK LOOP

If the blood glucose level is too low, the pancreas stops producing insulin and produces glucagon. The production of glucagon will signal the liver to release the glucose in glycogen so your body can use it.


Low Blood Glucose
High Blood Glucose
Pancreas
Glucagon Released by Cells of Pancreas
Insulin Released by Cells of Pancreas
Liver Releases Glucose into Blood
Fat Cells Take In Glucose from Blood
Achieve Normal Blood Glucose Levels

If the blood glucose level is too high, the pancreas secretes insulin. Insulin moves through the body and triggers fat cells to take in blood glucose and then signals the liver to store the glucose as glycogen.

POSITIVE FEEDBACK

Far less common

Accelerates a process

- Explosive system

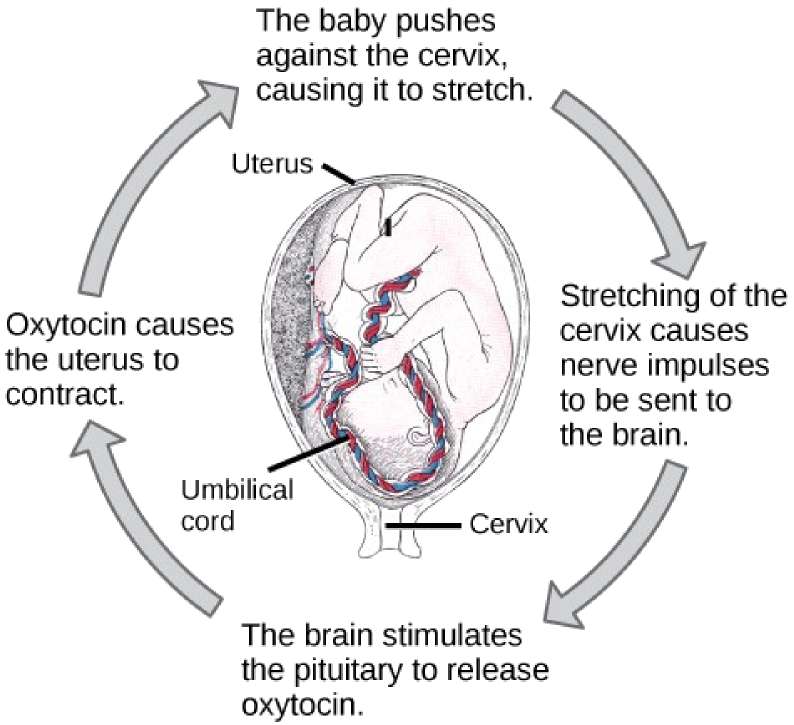
Reinforces the direction of the change

birth in mammals

blood clotting and platelets

Immune system B lymphocytes

FIGURE 33.21



The baby pushes against the cervix, causing it to stretch.

Stretching of the cervix causes nerve impulses to be sent to the brain.

The brain stimulates the pituitary to release oxytocin.

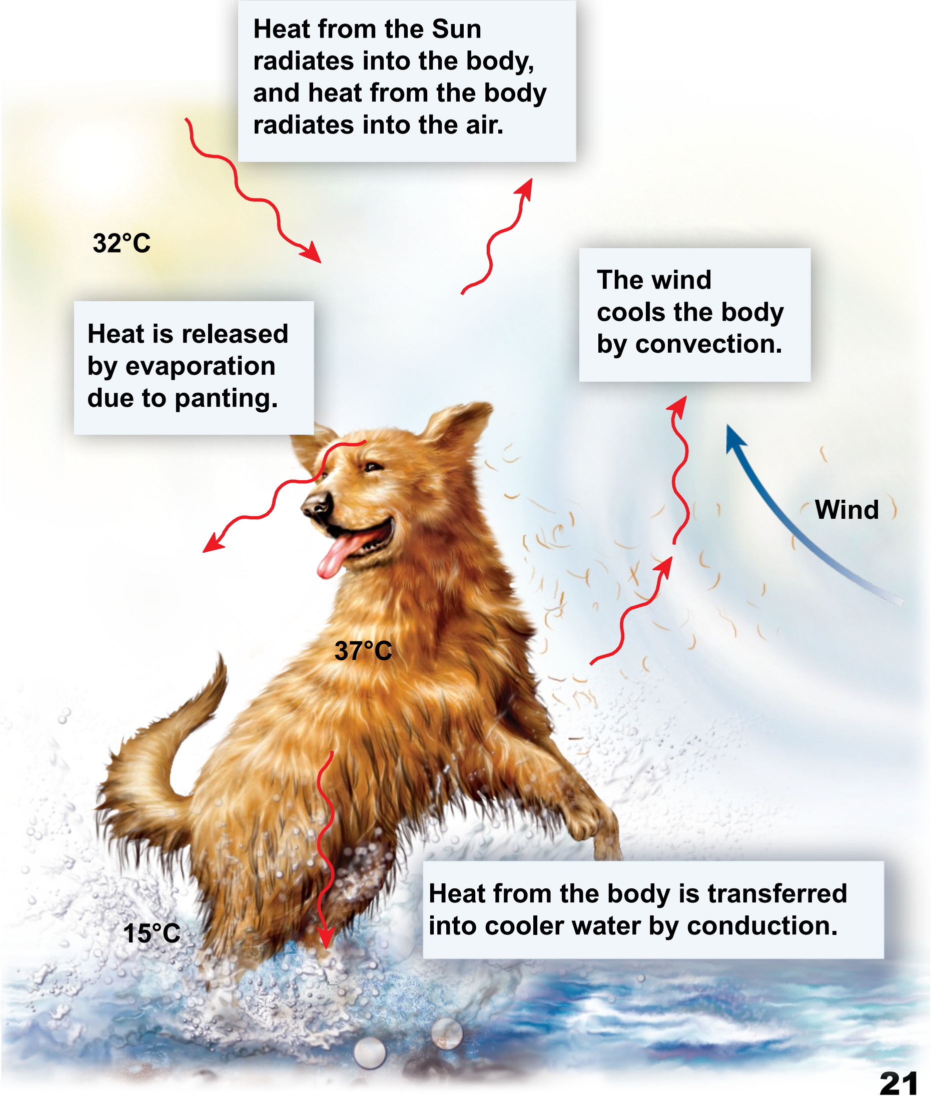
Oxytocin causes the uterus to contract.

The birth of a human infant is the result of **positive feedback**.

Another is the formation of platelets during wound clotting. 1st set of platelets are activated after wound in formed, and those platelets release a chemical signal to activate more platelets, until wound is clotted.

HEAT EXCHANGE 33.3

1. Radiation
2. Evaporation
3. Convection
4. Conduction



Heat from the Sun radiates into the body, and heat from the body radiates into the air.

Heat is released by evaporation due to panting.

The wind cools the body by convection.

Heat from the body is transferred into cooler water by conduction.

Elephant Thermoregulation

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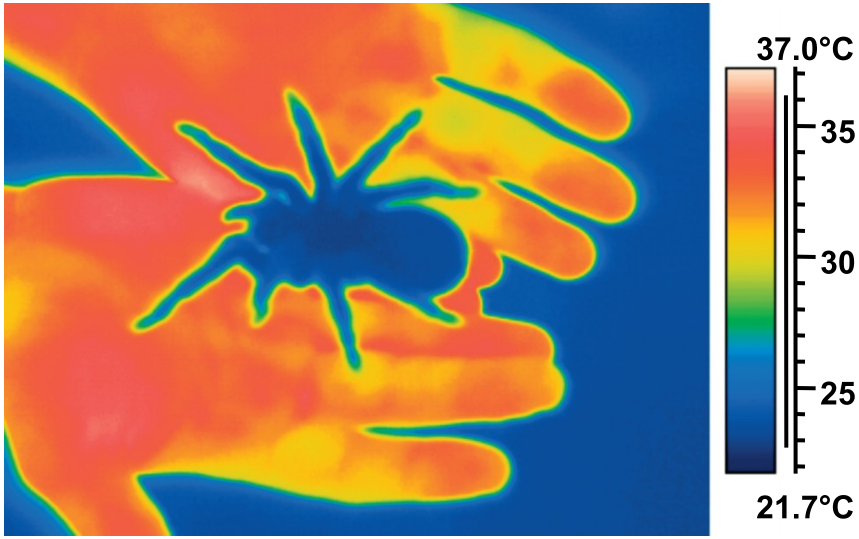

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Radiation

- Emission of electromagnetic waves by the surfaces of objects
- Rate determined by temperature of radiating surface

- 65% of body heat is lost due to radiation

Evaporation

- Whenever water vaporizes from the body’s surface, the heat energy required to drive the process (liquid to gas). Heat is conducted from the surface, thereby cooling the animal. (Sweating is one possibility)

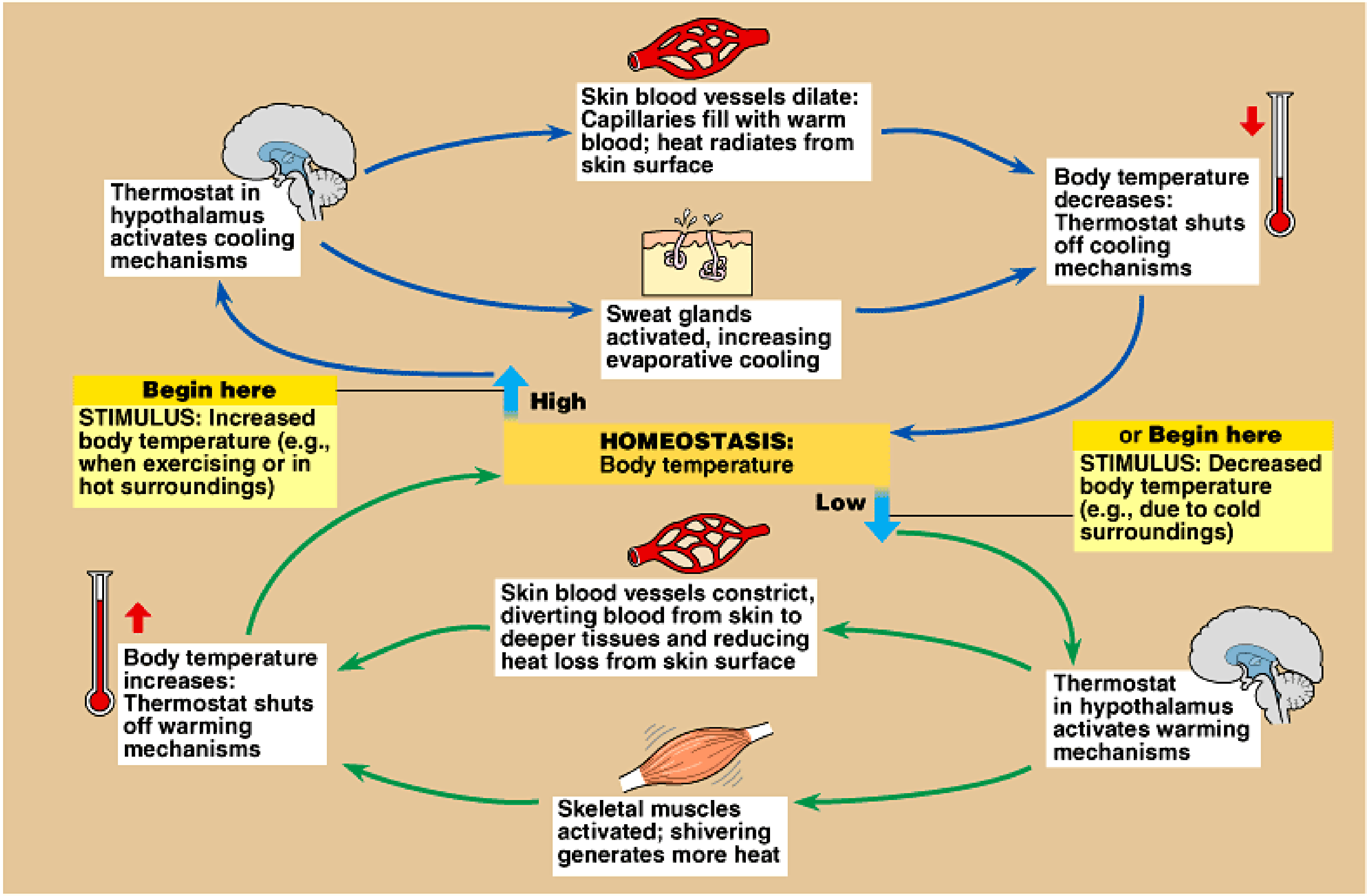
Convection

- Transfer of heat (thermal energy) by the movement of air or water next to the body
- Sitting near fans, bat flapping wings, or elephant waving ears
- Surface area important – elephant ears or bat wings

Conduction

- Body surface loses or gains heat through direct contact with cooler or warmer substances
- Water has a higher heat capacity than air (slower to lose temperature) and can cool a body more quickly than the air. Patients with high fever may be placed in cool water to quickly lower core body temperature.

THE THERMOSTAT FUNCTION OF THE HYPOTHALAMUS AND FEEDBACK MECHANISMS IN HUMAN THERMOREGULATION – AN EXAMPLE OF NEGATIVE FEEDBACK



Thermostat in hypothalamus activates cooling mechanisms

Skin blood vessels dilate: Capillaries fill with warm blood; heat radiates from skin surface

Sweat glands activated, increasing evaporative cooling

Body temperature decreases: Thermostat shuts off cooling mechanisms

Begin here

STIMULUS: Increased body temperature (e.g., when exercising or in hot surroundings)

High

HOMEOSTASIS:
Body temperature

Low

or **Begin here**

STIMULUS: Decreased body temperature (e.g., due to cold surroundings)

Skin blood vessels constrict, diverting blood from skin to deeper tissues and reducing heat loss from skin surface

Thermostat in hypothalamus activates warming mechanisms

Skeletal muscles activated; shivering generates more heat

Body temperature increases: Thermostat shuts off warming mechanisms

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Endotherms (such as mammals) can adapt to chronic temperature changes

- **Acclimatization** – fine-tuning of adaptive mechanisms
- Person newly arriving in hot climate has trouble coping
- After a few days or weeks, acclimatization occurs
    - Sweating begins sooner and is greater in volume

Animal Nutrition and the Digestive System

Ch 41

Nutrition – process of consuming and using food and nutrients

Nutrient – any substance consumed by an animal that is needed for survival, growth, development, tissue repair, or reproduction

All organisms require nutrients to survive

ANIMALS REQUIRE

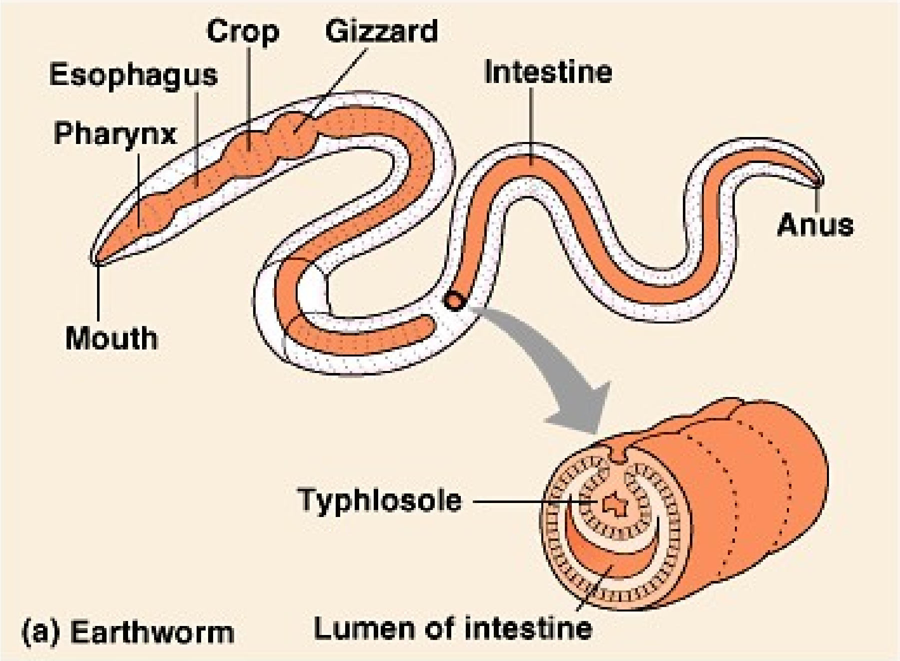
Five categories of organic nutrients

- **Carbohydrates**
- **Proteins**
- **Lipids**
- **Nucleic acids**
- **Vitamins**

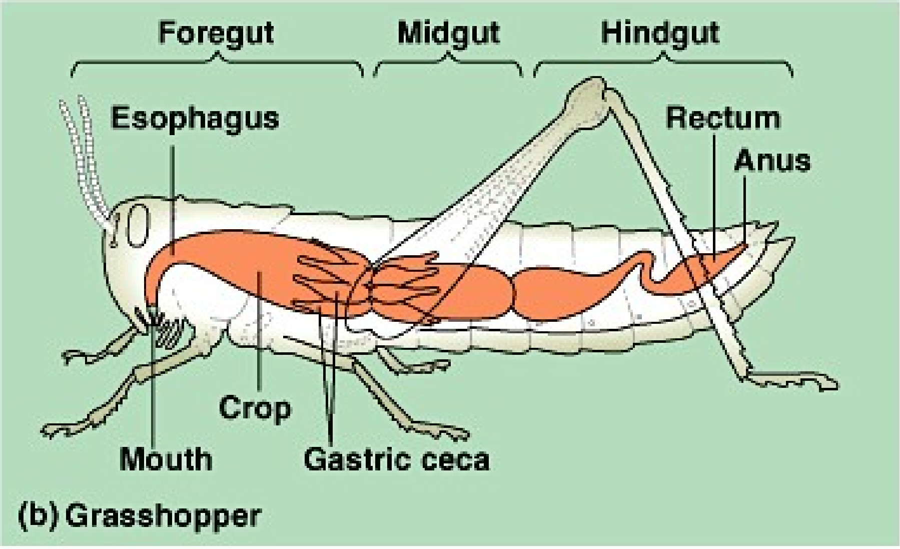
Inorganic nutrients

- **Water and minerals**

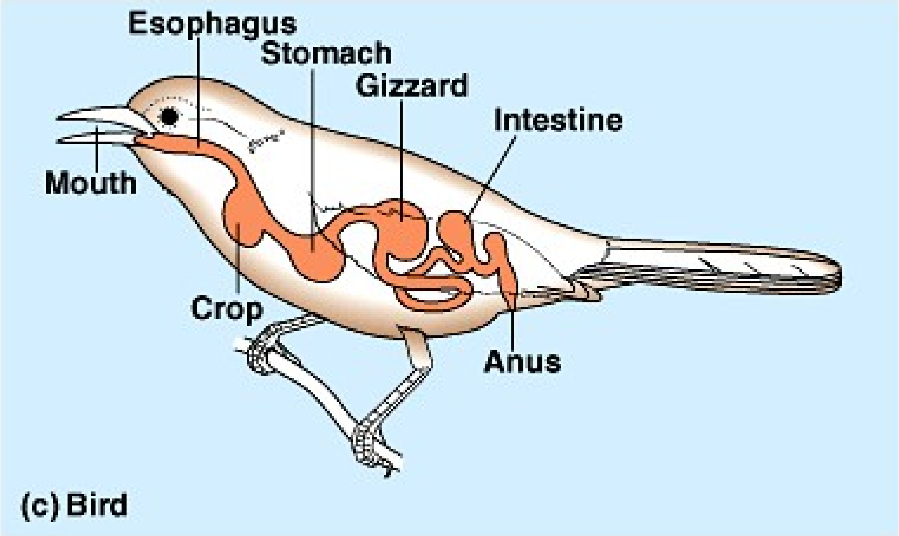
ALIMENTARY CANALS – DIGESTIVE TRACTS



(a) Earthworm



(b) Grasshopper



(c) Bird

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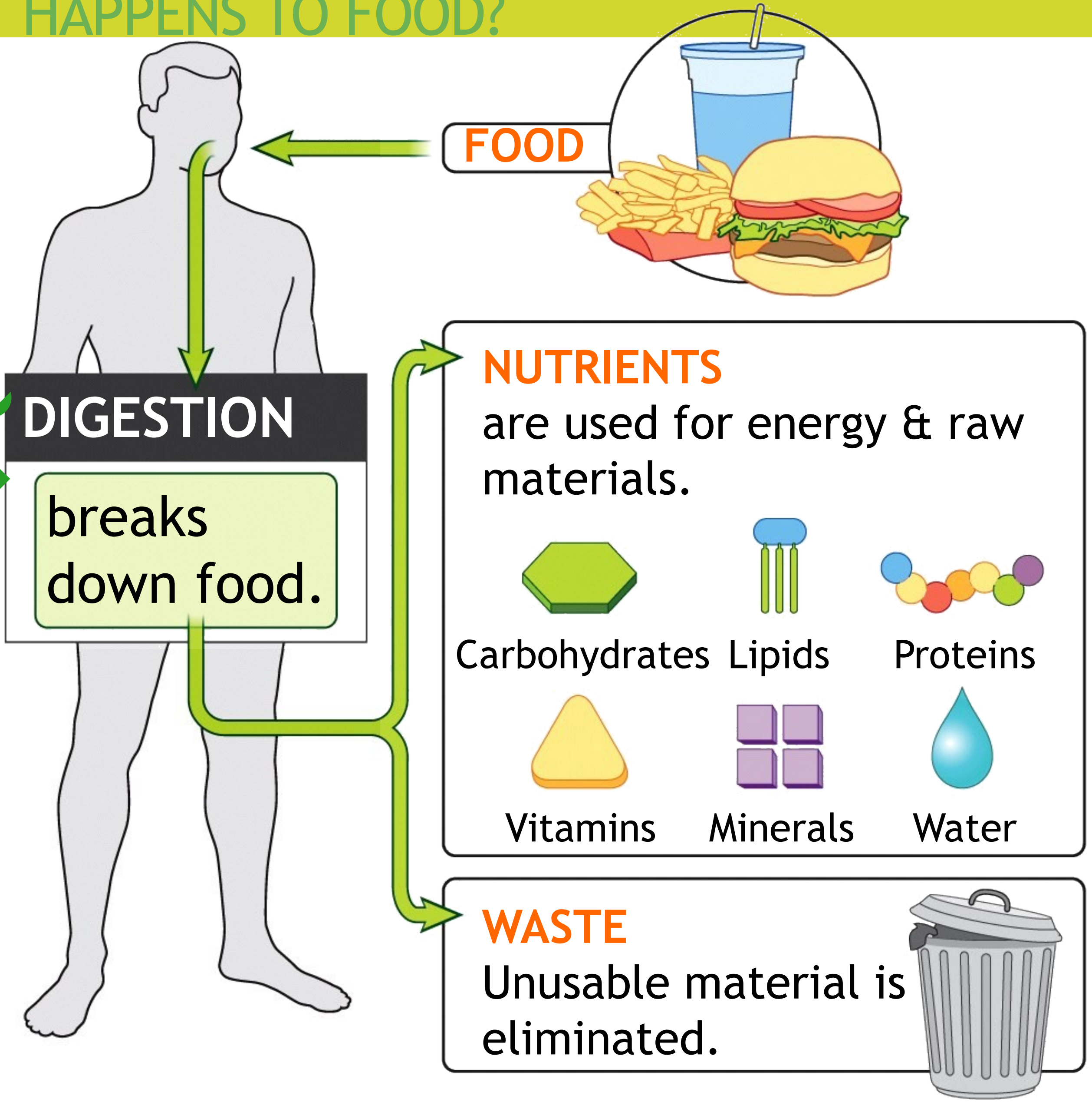
FOOD CHOICE & DIGESTION: WHAT HAPPENS TO FOOD?

What kinds of food we can eat depends on the digestive enzymes we have to break food down into its nutrients.



FOOD

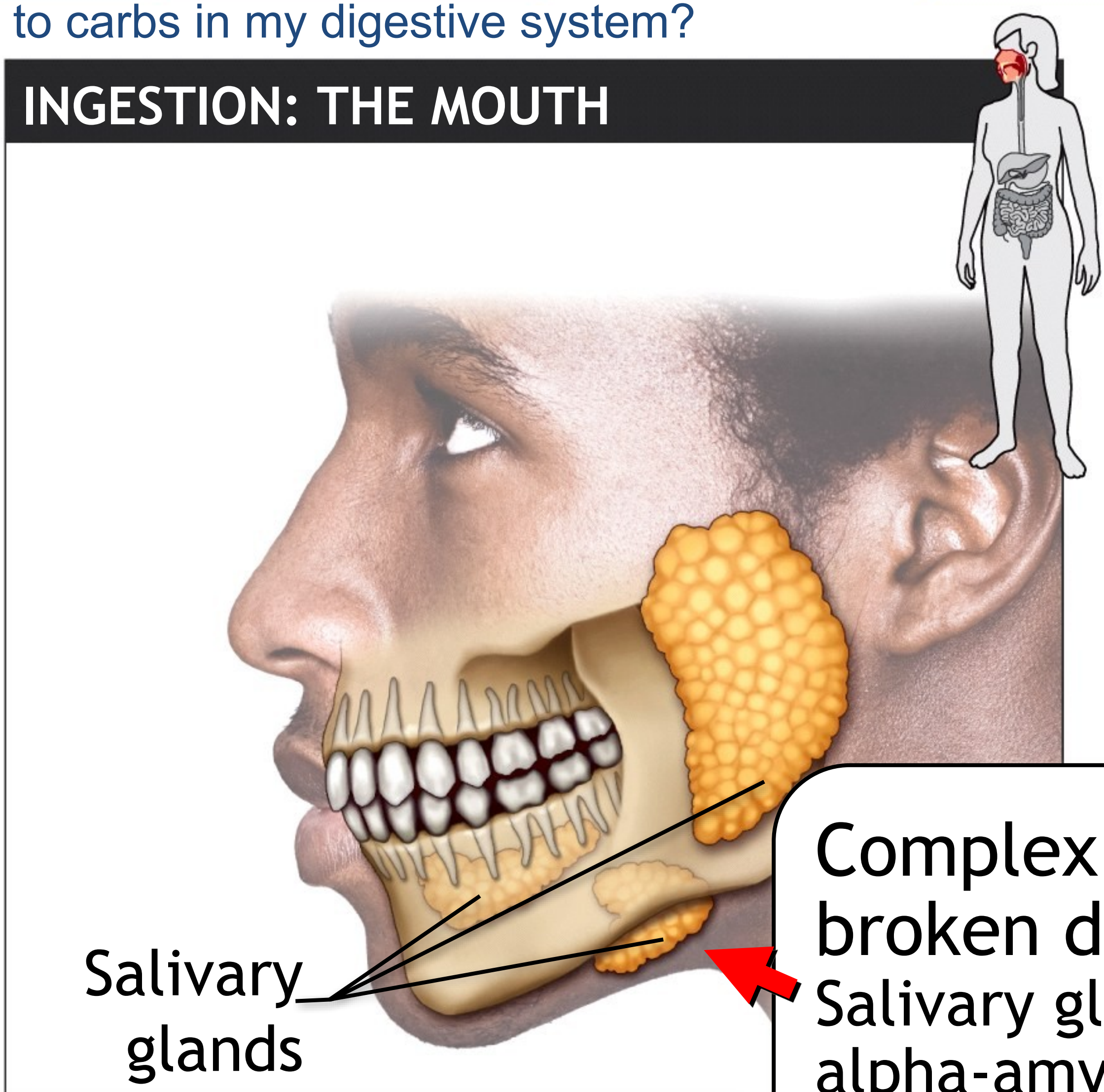
DIGESTION

breaks down food.

NUTRIENTS
are used for energy & raw materials.

WASTE
Unusable material is eliminated.

t happens to carbs in my digestive system?

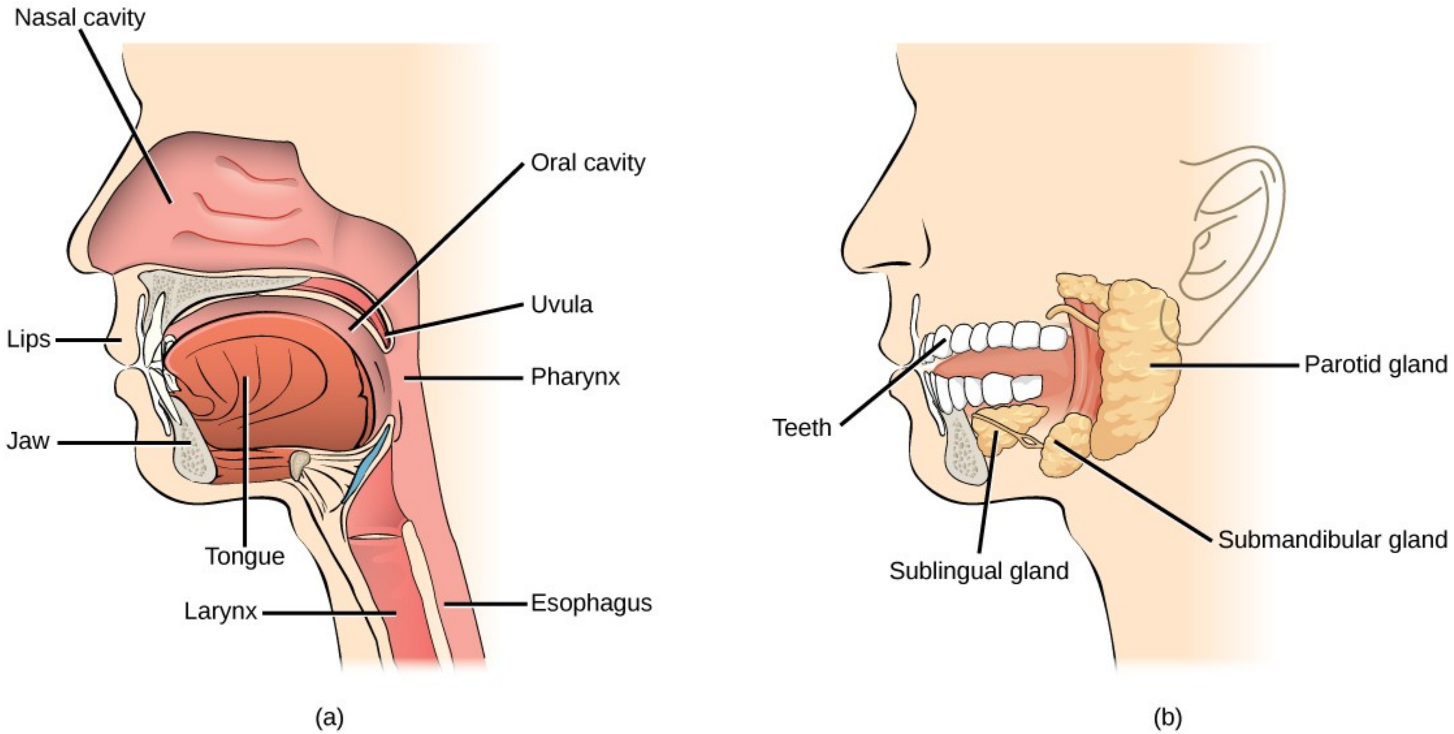


Complex carbs are broken down:

Salivary glands release alpha-amylase, an enzyme that breaks down starch.

Tongue and teeth help to mechanically digest the carbs

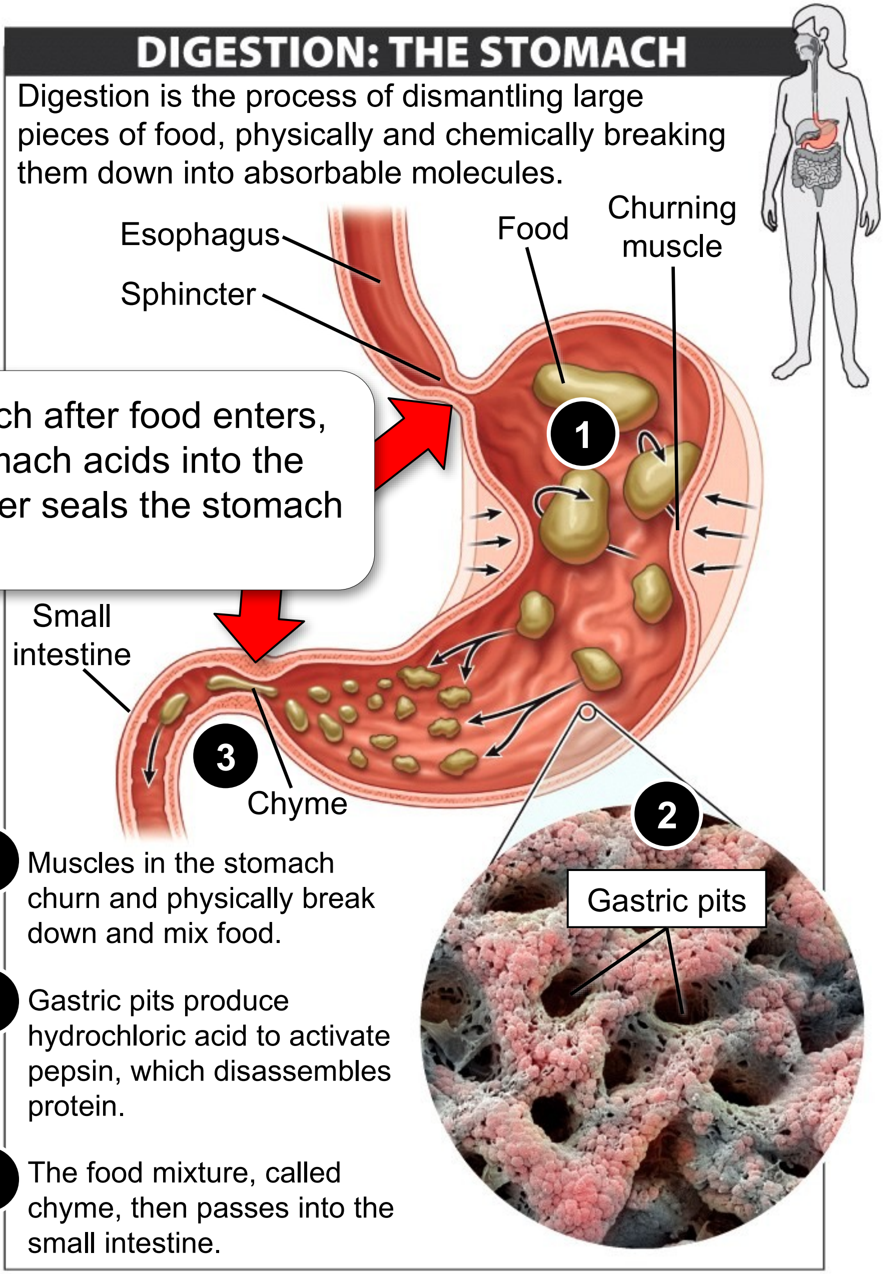
FIGURE 34.9



Digestion of food begins in the (a) oral cavity. Food is masticated by teeth and moistened by saliva secreted from the (b) salivary glands. Enzymes in the saliva begin to digest starches and fats. With the help of the tongue, the resulting bolus is moved into the esophagus by swallowing. (credit: modification of work by the National Cancer Institute)

DIGESTION: THE STOMACH

Digestion is the process of dismantling large pieces of food, physically and chemically breaking them down into absorbable molecules.



A sphincter seals the stomach after food enters, preventing back-flow of stomach acids into the esophagus. Another sphincter seals the stomach from the small intestine.

1. Muscles in the stomach churn and physically break down and mix food.
2. Gastric pits produce hydrochloric acid to activate pepsin, which disassembles protein.
3. The food mixture, called chyme, then passes into the small intestine.

Figure 22-20

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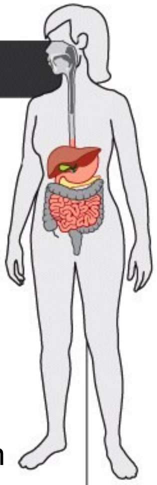
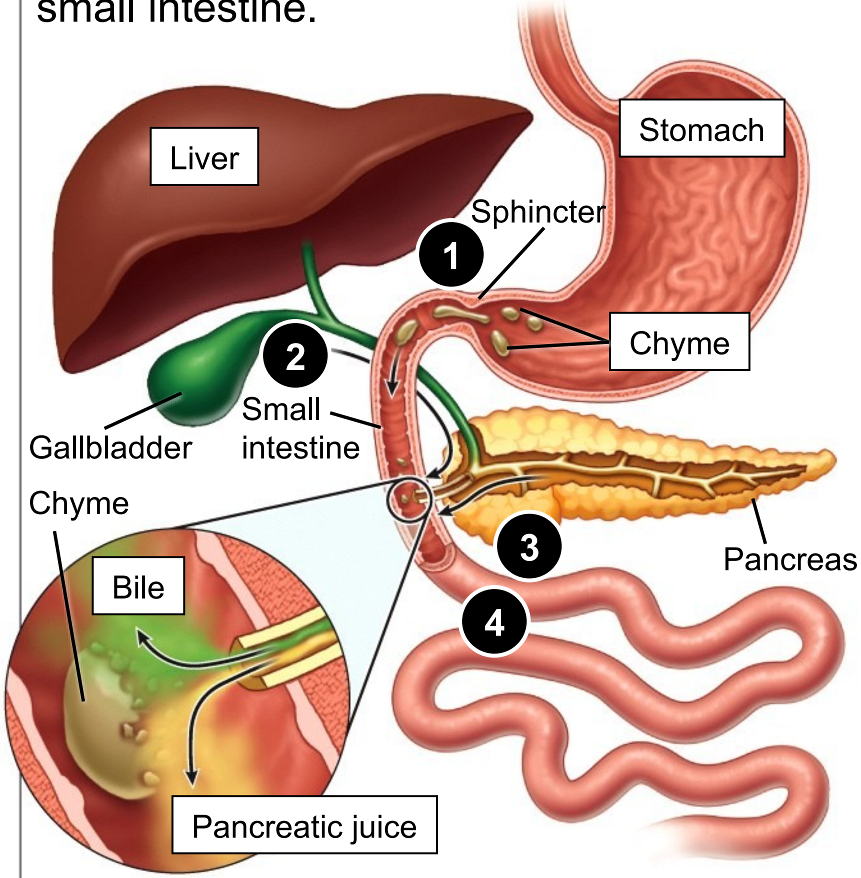
DIGESTION: THE SMALL INTESTINE



Although digestion begins in the mouth and stomach, most of it occurs in the small intestine.



1 As a sphincter at the end of the stomach relaxes, small amounts of chyme are squirted into the small intestine.

2 The liver produces bile, which travels from the gallbladder, where it is stored, to the small intestine, where it separates globules of fat into tiny, more easily digested and absorbed droplets.

3 The pancreas secretes pancreatic juice, which neutralizes the chyme and aids in the digestion of carbohydrates, proteins, and fats.

4 Cells within the walls of the small intestine produce enzymes that further digest fats, carbohydrates, and proteins.

Digestion is completed in the small intestine, at which point carbohydrates, proteins, and fats have been broken down into simple sugars, amino acids, and fatty acids.

Figure 22-21

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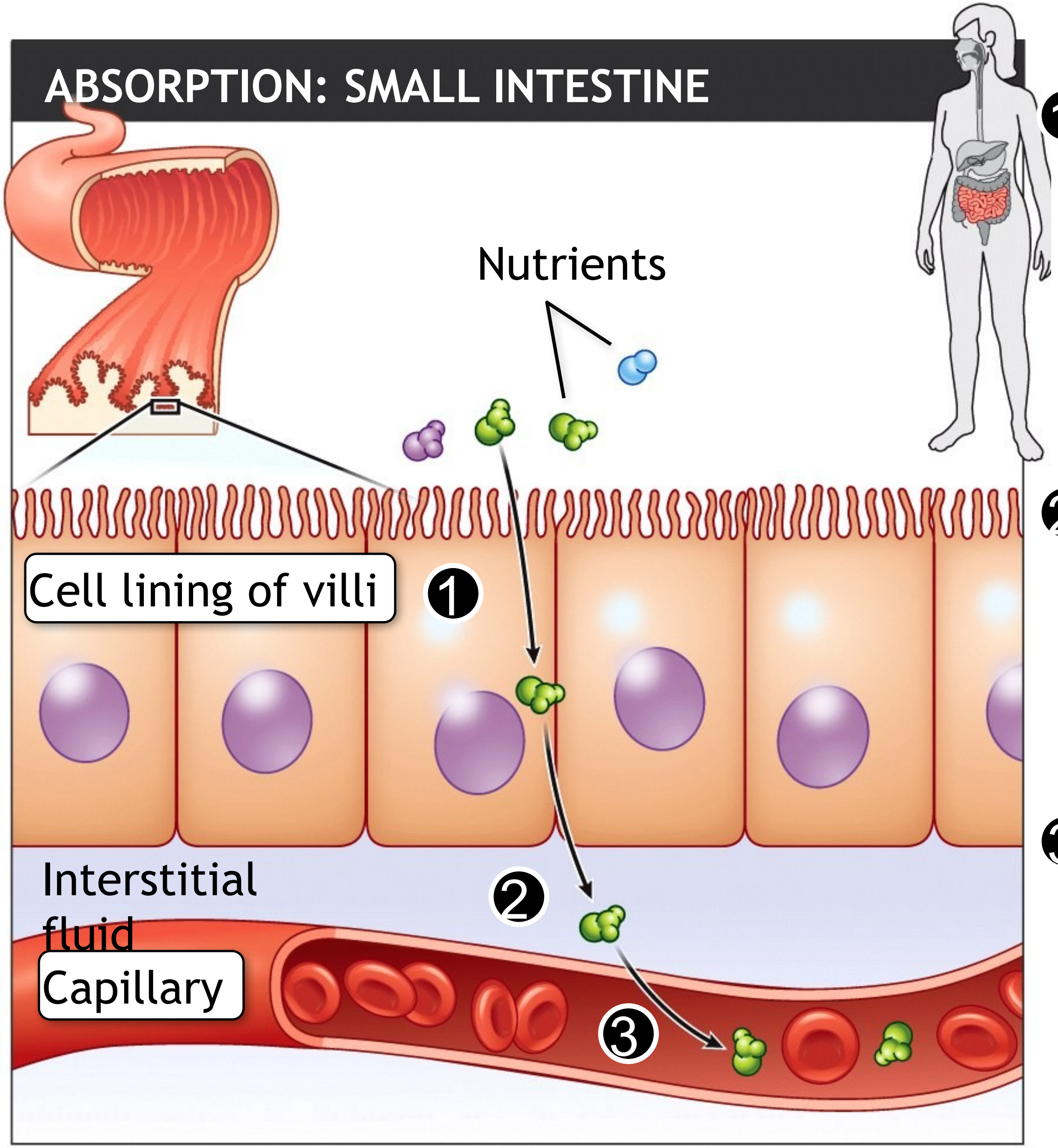
ABSORPTION: SMALL INTESTINE

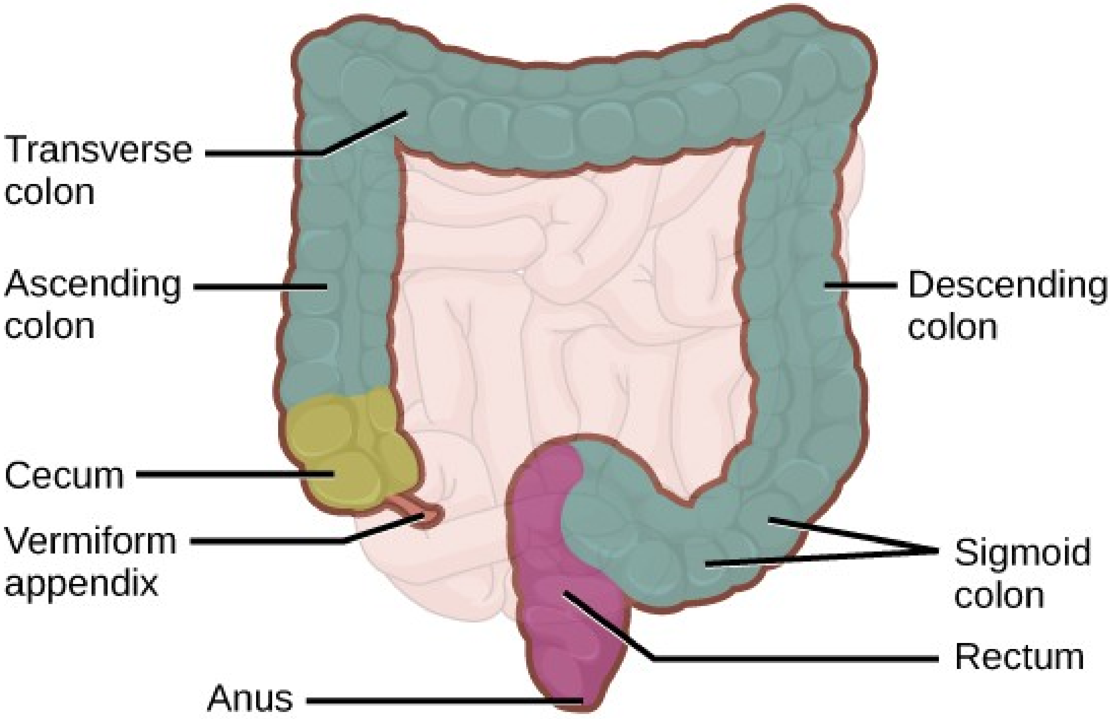


❶ **Sugars (amino acids, fats, vitamins and minerals)** are **transported into** the **cells** that form the small intestine wall.

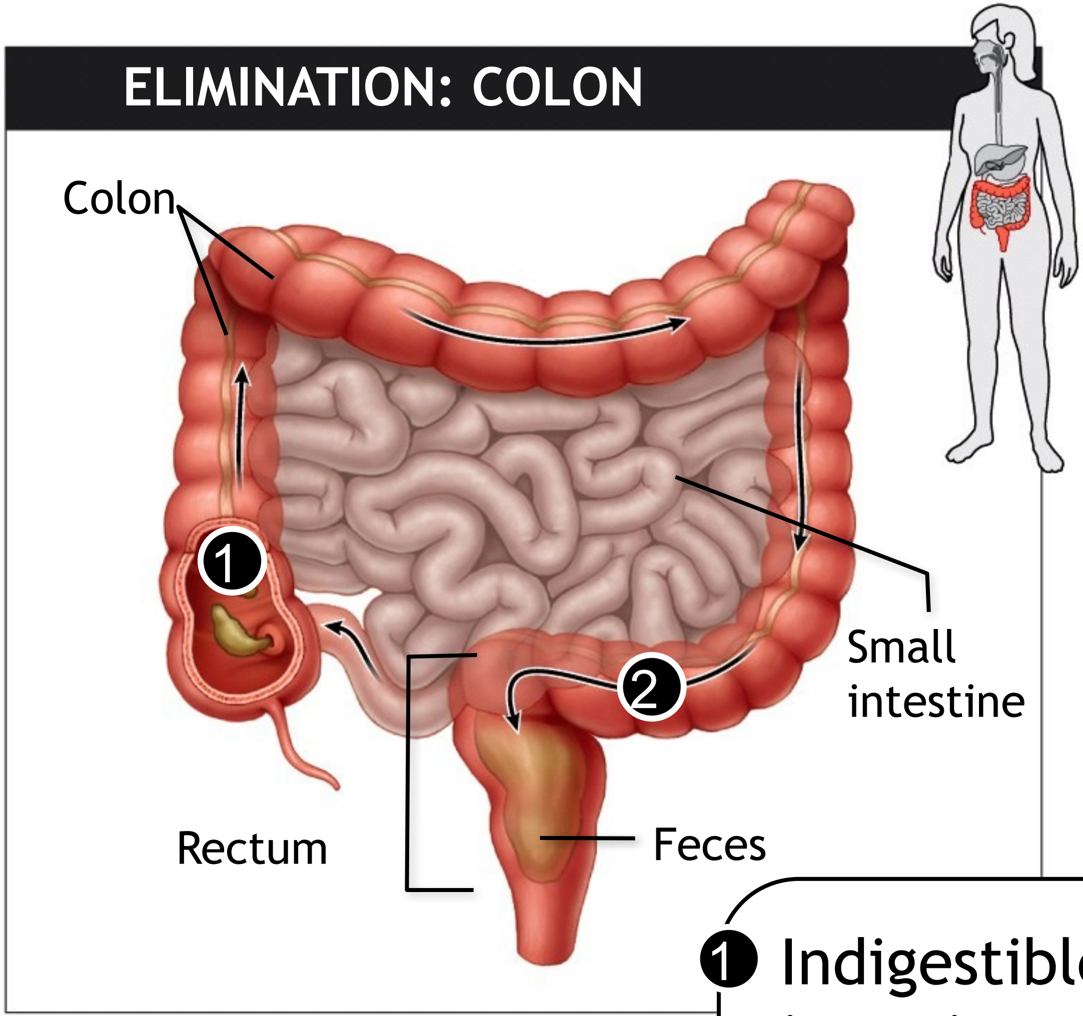
❷ They diffuse out of the cells and into the interstitial fluid.

❸ They are picked up by capillaries and move into bloodstream.

FIGURE 34.13



The large intestine reabsorbs water from undigested food and stores waste material until it is eliminated.



Water, salts, some vitamins are absorbed.

❶ Indigestible fibers leave small intestine and enter the large intestine, or colon.

❷ **Fibers are eliminated** at the rectum as feces.

ENZYMATIC DIGESTION IN THE HUMAN DIGESTIVE SYSTEM

	(a) Carbohydrate digestion	(b) Protein digestion	(c) Nucleic acid digestion	(d) Fat digestion
Oral cavity, pharynx, esophagus	Polysaccharides (starch, glycogen) ↓ **Salivary amylase** Smaller polysaccharides, maltose			
Stomach		Proteins ↓ **Pepsin** Small polypeptides		
Lumen of small intestine	Polysaccharides ↓ **Pancreatic amylases** Maltose and other disaccharides ↓	↓ Polypeptides ↓ **Trypsin, Chymotrypsin** Smaller polypeptides ↓ **Aminopeptidase, Carboxypeptidase** Amino acids	DNA, RNA ↓ **Nucleases** Nucleotides ↓	Fat globules ↓ **Bile salts** Fat droplets (emulsified) ↓ **Lipase** Glycerol, fatty acids, glycerides
Epithelium of small intestine (brush border)	↓ **Disaccharidases** Monosaccharides	Small peptides ↓ **Dipeptidases** Amino acids	↓ **Nucleotidases** Nucleosides ↓ **Nucleosidases** Nitrogenous bases, sugars, phosphates	

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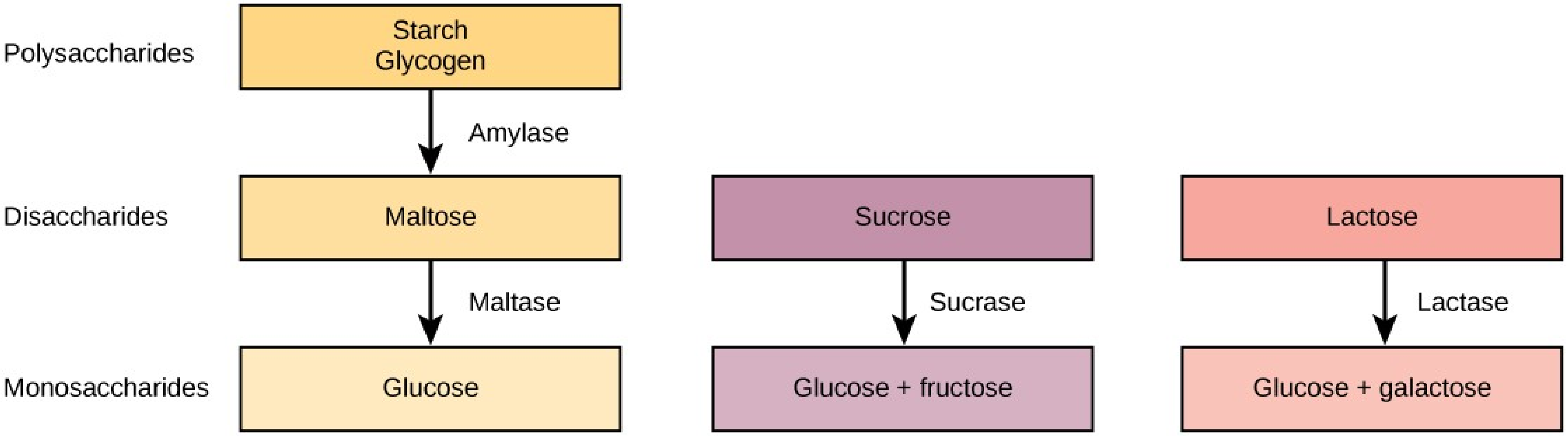
FIGURE 34.16



Digestion of carbohydrates is performed by several enzymes. Starch and glycogen are broken down into glucose by amylase and maltase. Sucrose (table sugar) and lactose (milk sugar) are broken down by sucrase and lactase, respectively.

FIGURE 34.17

Protein digestion is a multistep process that begins in the stomach and continues through the intestines.

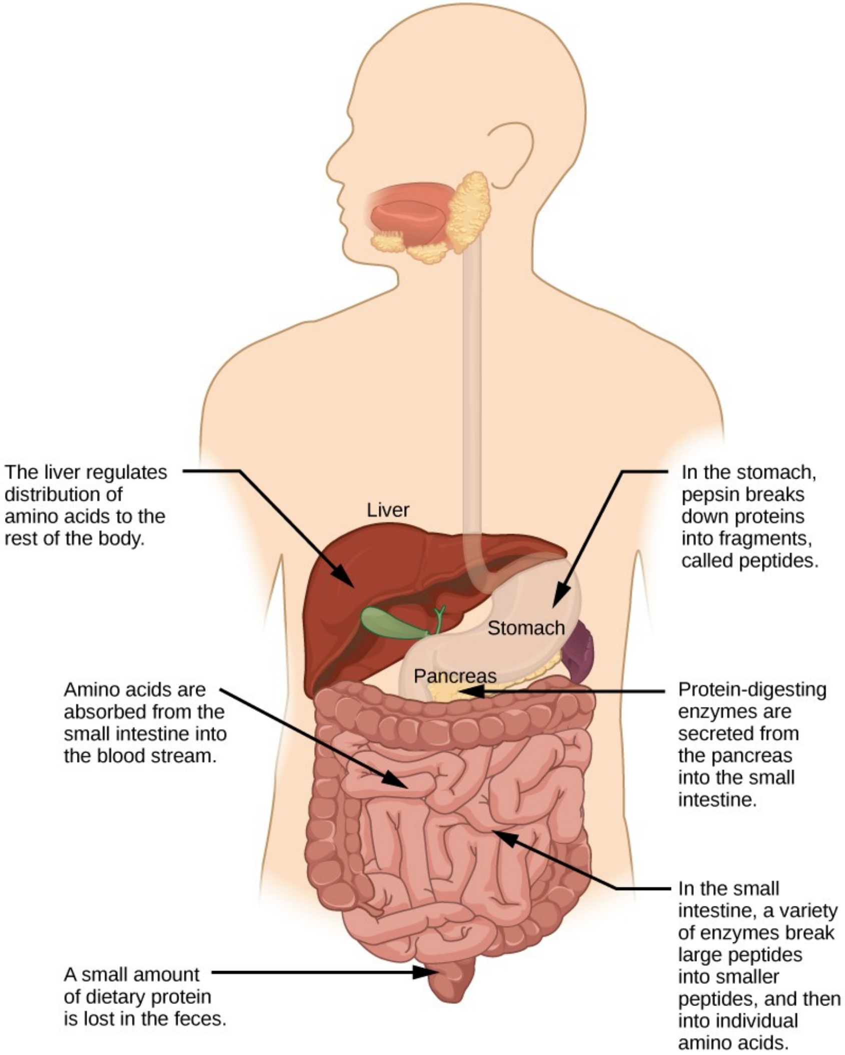
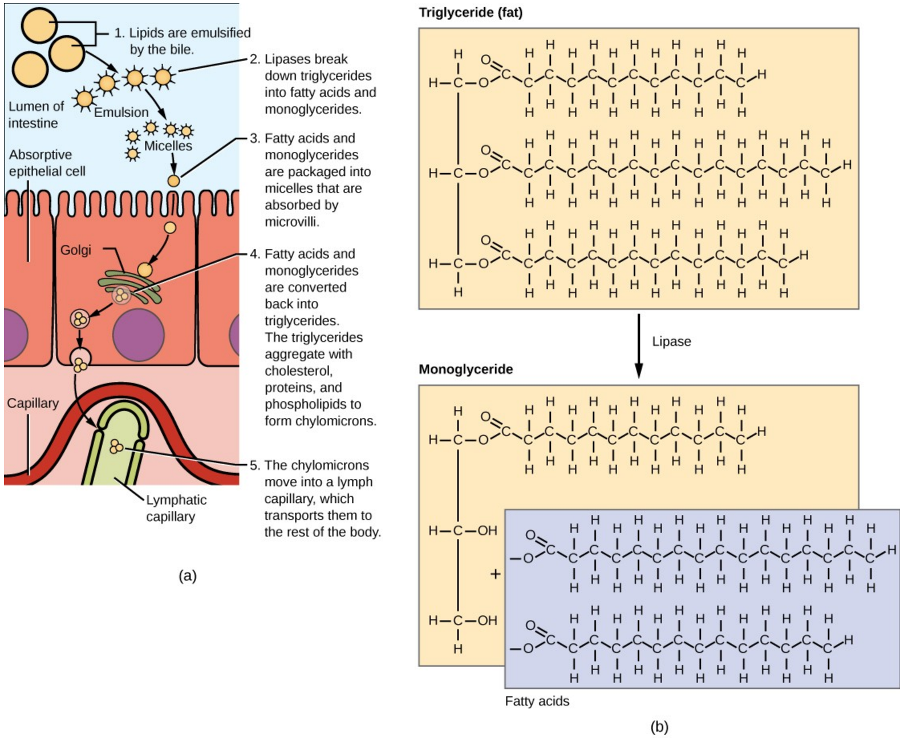

The liver regulates distribution of amino acids to the rest of the body.
Liver
In the stomach, pepsin breaks down proteins into fragments, called peptides.
Stomach
Pancreas
Amino acids are absorbed from the small intestine into the blood stream.
Protein-digesting enzymes are secreted from the pancreas into the small intestine.
In the small intestine, a variety of enzymes break large peptides into smaller peptides, and then into individual amino acids.
A small amount of dietary protein is lost in the feces.

FIGURE 34.18



1. Lipids are emulsified by the bile.
2. Lipases break down triglycerides into fatty acids and monoglycerides.
3. Fatty acids and monoglycerides are packaged into micelles that are absorbed by microvilli.
4. Fatty acids and monoglycerides are converted back into triglycerides. The triglycerides aggregate with cholesterol, proteins, and phospholipids to form chylomicrons.
5. The chylomicrons move into a lymph capillary, which transports them to the rest of the body.

Lipids are digested and absorbed in the small intestine.

THE DIGESTIVE TRACTS OF A CARNIVORE (COYOTE) AND A HERBIVORE (KOALA) COMPARED

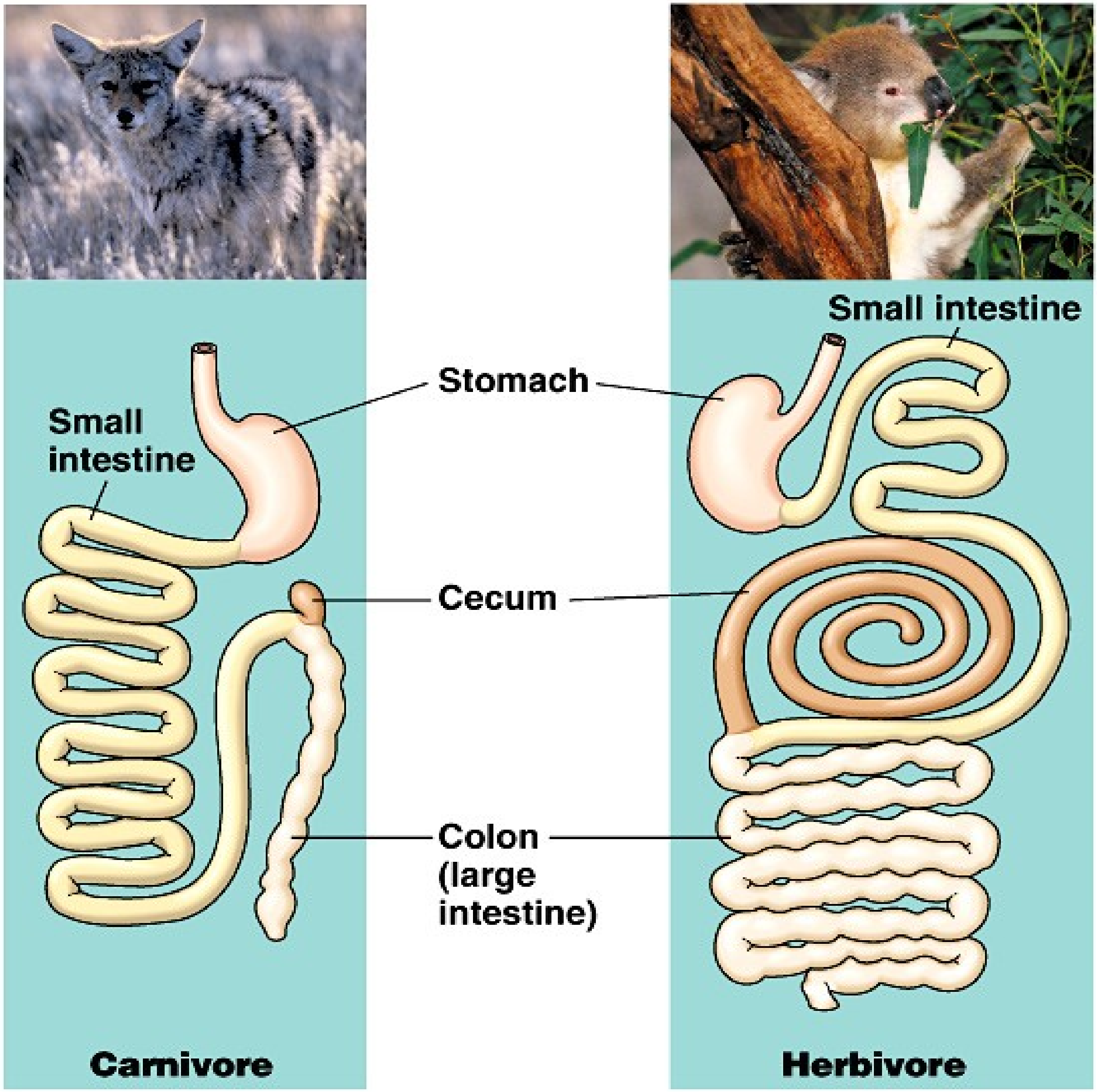


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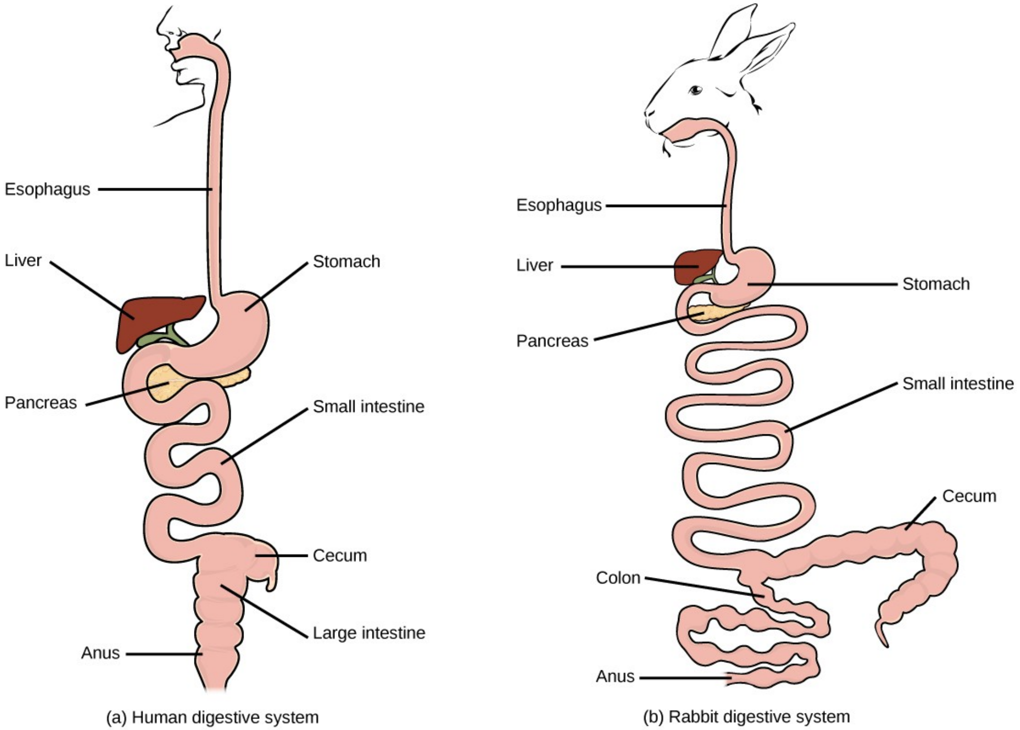
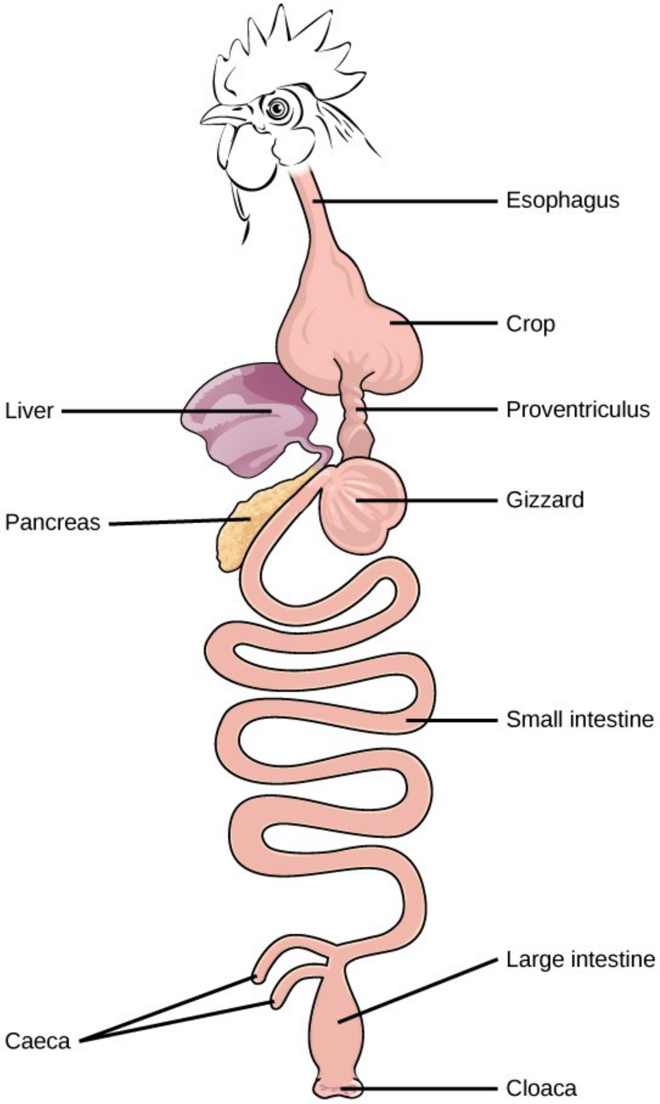
FIGURE 34.6



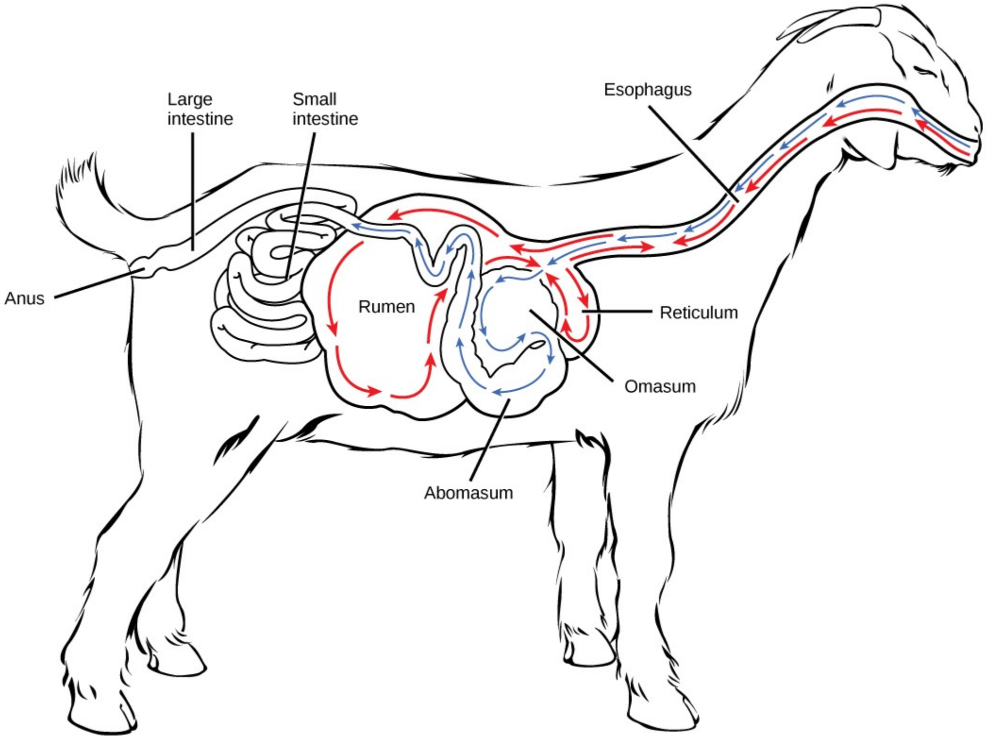
(a) Humans and herbivores, such as the (b) rabbit, have a monogastric digestive system. However, in the rabbit the small intestine and cecum are enlarged to allow more time to digest plant material. The enlarged organ provides more surface area for absorption of nutrients. Rabbits digest their food twice: the first time food passes through the digestive system, it collects in the cecum, and then it passes as soft feces called cecotrophes. The rabbit re-ingests these cecotrophes to further digest them.

FIGURE 34.7



The avian esophagus has a pouch, called a crop, which stores food. Food passes from the crop to the first of two stomachs, called the proventriculus, which contains digestive juices that break down food. From the proventriculus, the food enters the second stomach, called the gizzard, which grinds food. Some birds swallow stones or grit, which are stored in the gizzard, to aid the grinding process. Birds do not have separate openings to excrete urine and feces. Instead, uric acid from the kidneys is secreted into the large intestine and combined with waste from the digestive process. This waste is excreted through an opening called the cloaca.

FIGURE 34.8



Ruminant animals, such as goats and cows, have four stomachs. The first two stomachs, the rumen and the reticulum, contain prokaryotes and protists that are able to digest cellulose fiber. The ruminant regurgitates cud from the reticulum, chews it, and swallows it into a third stomach, the omasum, which removes water. The cud then passes onto the fourth stomach, the abomasum, where it is digested by enzymes produced by the ruminant.

RUMINANT DIGESTION

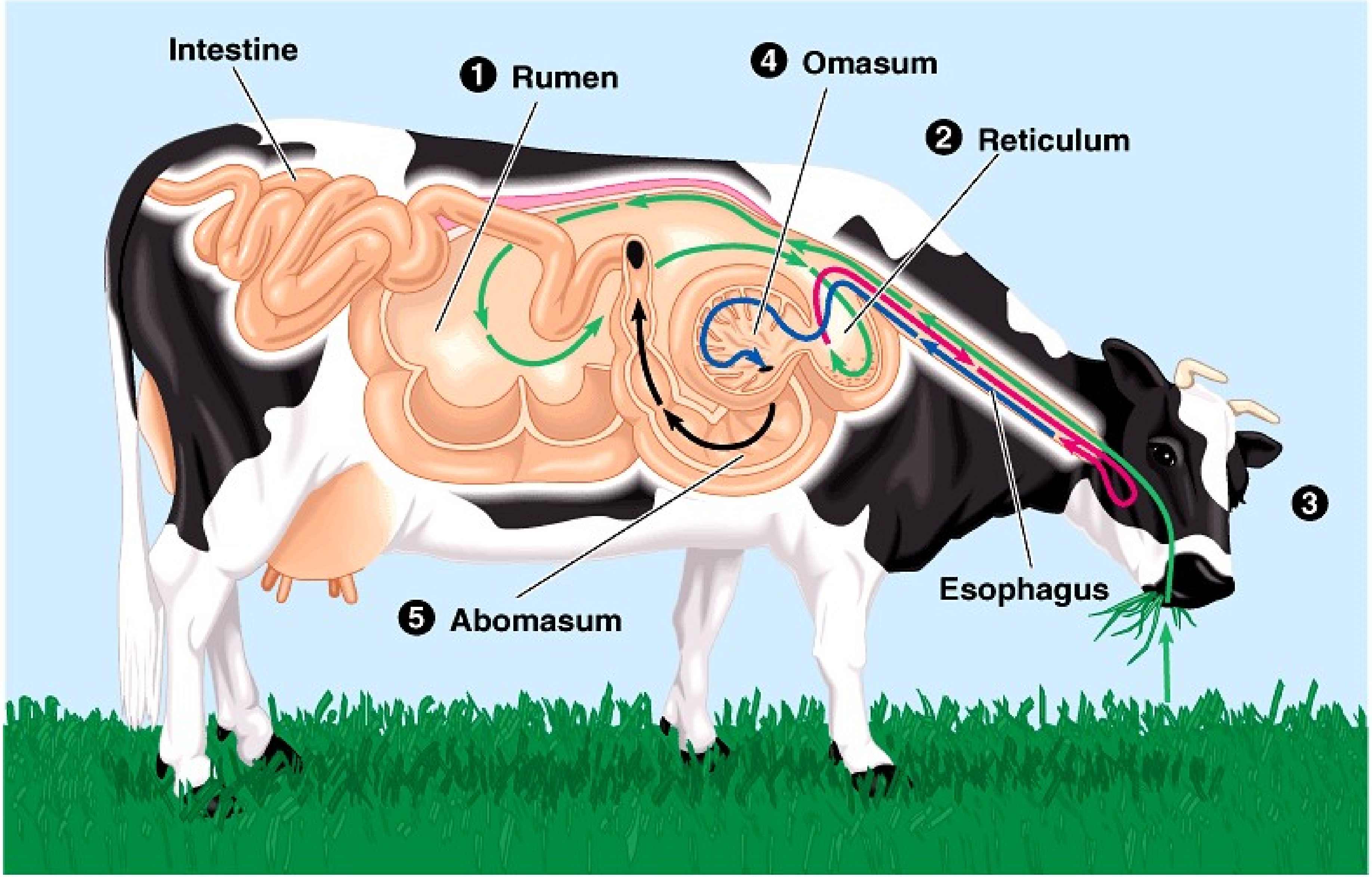


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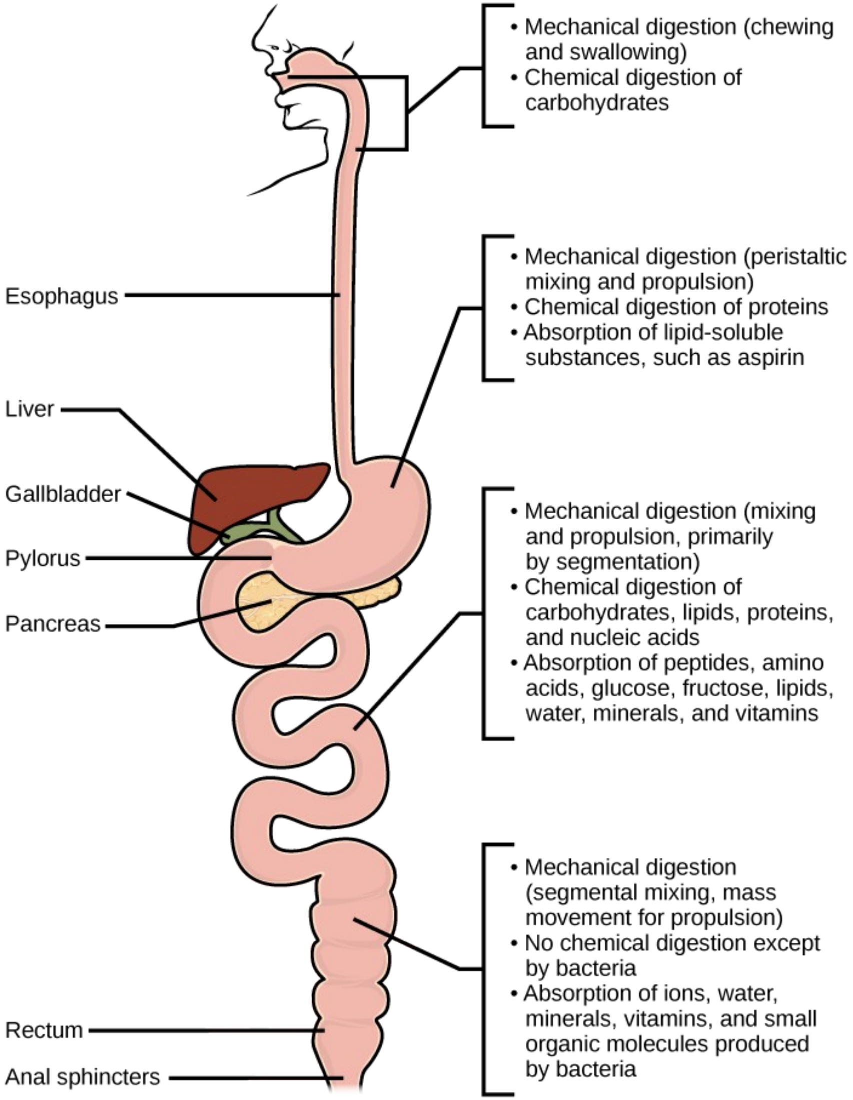
FIGURE 34.19



- Mechanical digestion (chewing and swallowing)
- Chemical digestion of carbohydrates

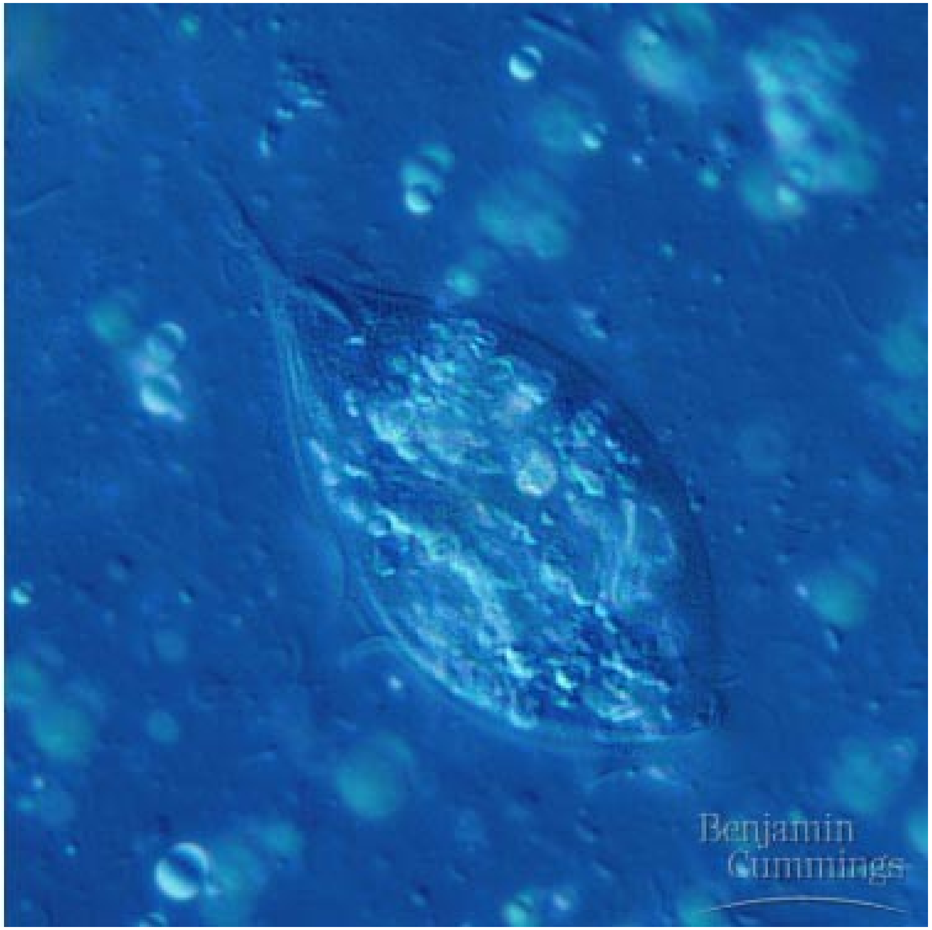
- Mechanical digestion (peristaltic mixing and propulsion)
- Chemical digestion of proteins
- Absorption of lipid-soluble substances, such as aspirin

- Mechanical digestion (mixing and propulsion, primarily by segmentation)
- Chemical digestion of carbohydrates, lipids, proteins, and nucleic acids
- Absorption of peptides, amino acids, glucose, fructose, lipids, water, minerals, and vitamins

- Mechanical digestion (segmental mixing, mass movement for propulsion)
- No chemical digestion except by bacteria
- Absorption of ions, water, minerals, vitamins, and small organic molecules produced by bacteria

Mechanical and chemical digestion of food takes place in many steps, beginning in the mouth and ending in the rectum.

TERMITE AND *TRICHONYMPHA (A PARABASILID)-EXCAVATA. W/FLAGELLA*



Have enzyme cellulase to break down cellulose with other enzymes.

Types of Circulatory Systems
Ch. 42

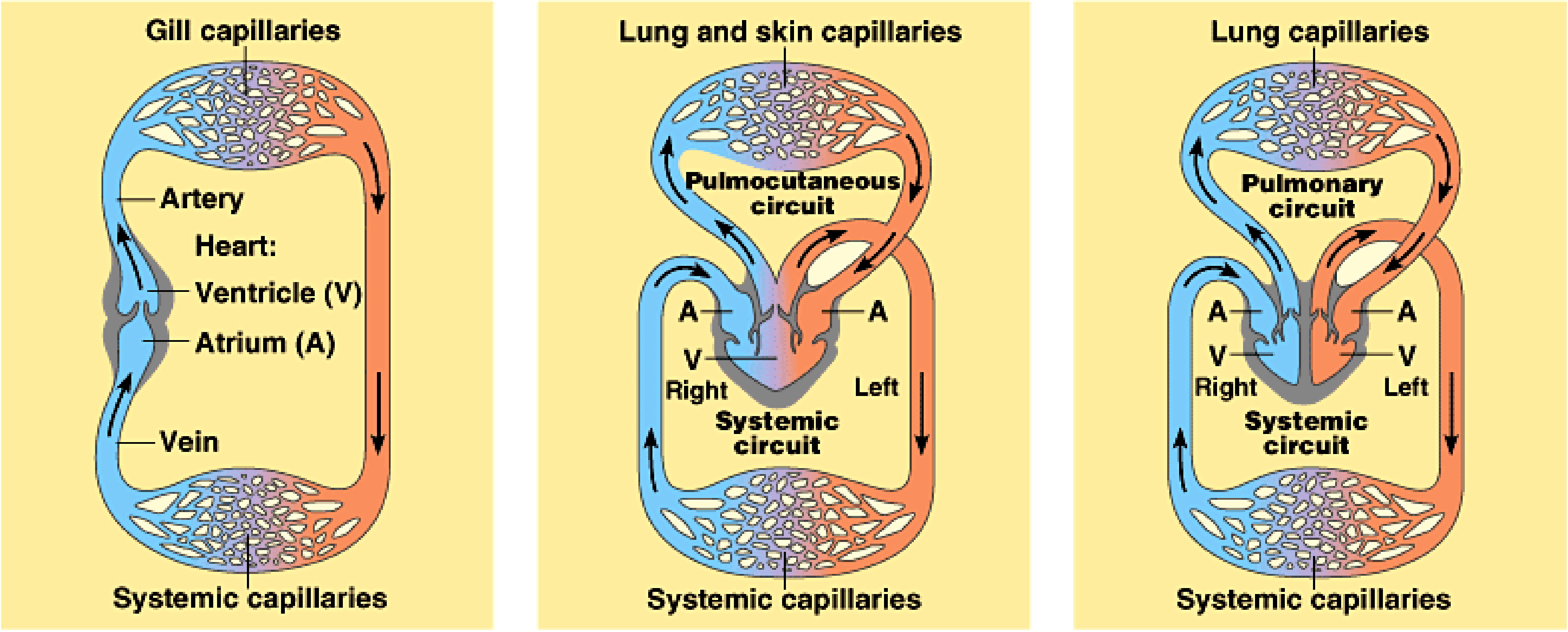
Primary function of a circulatory system is

- Transport necessary materials to the cells of an animal's body
- Transport waste products away from cells so they can be released into the environment

Three basic types

- **Gastrovascular cavity**
- **Open circulatory system**
- **Closed circulatory system**

GENERALIZED CIRCULATORY SCHEMES OF VERTEBRATES



(a) Fish (b) Amphibian (c) Mammal

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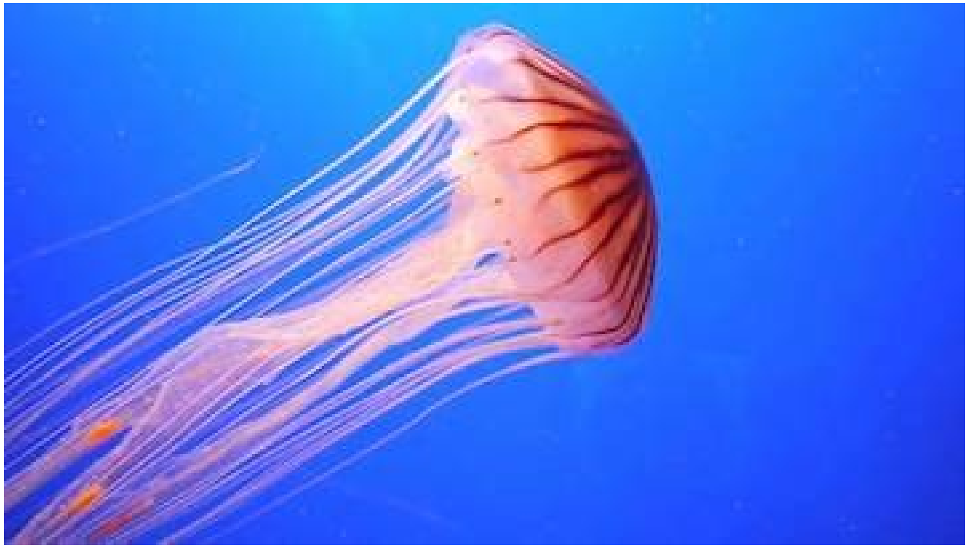
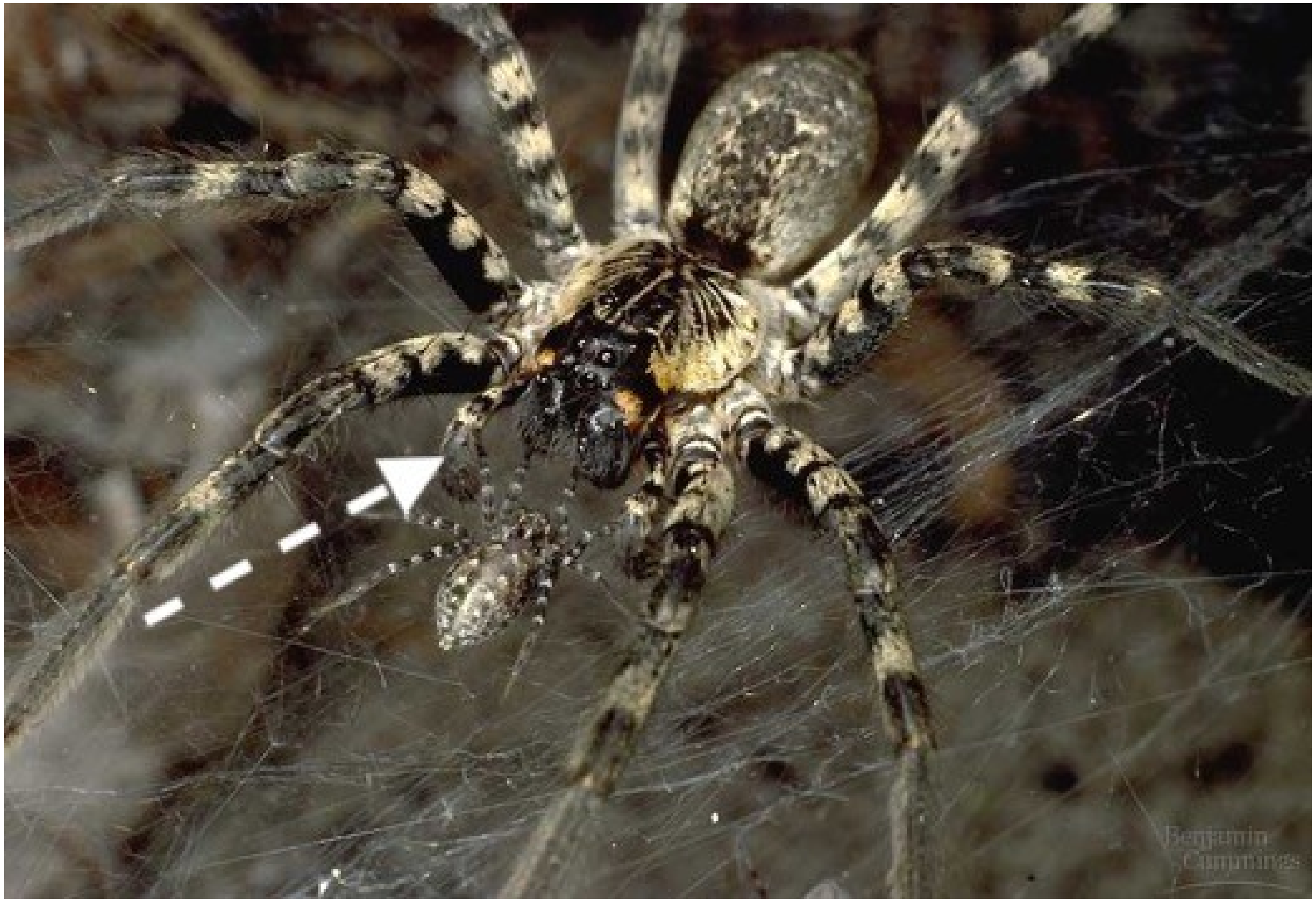
GUESS THE CIRCULATORY SYSTEM





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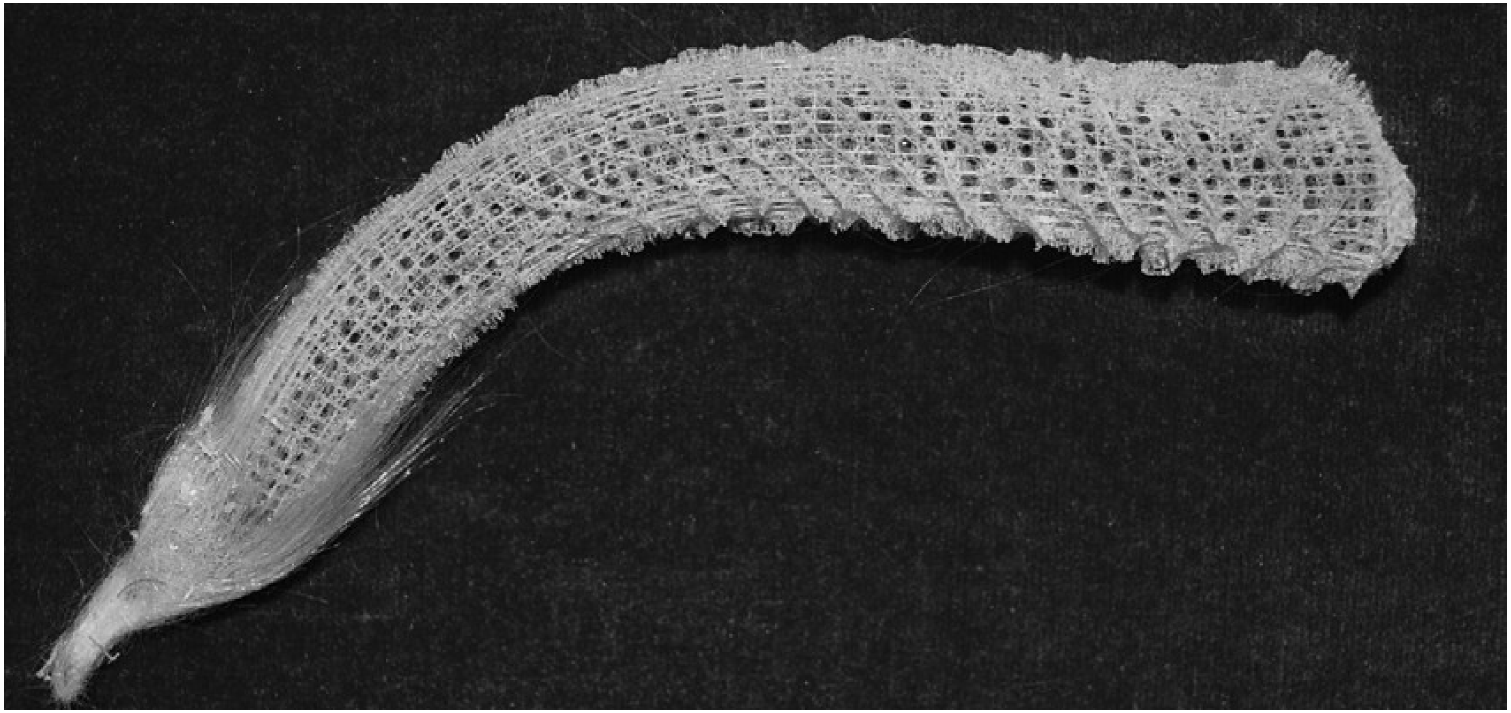
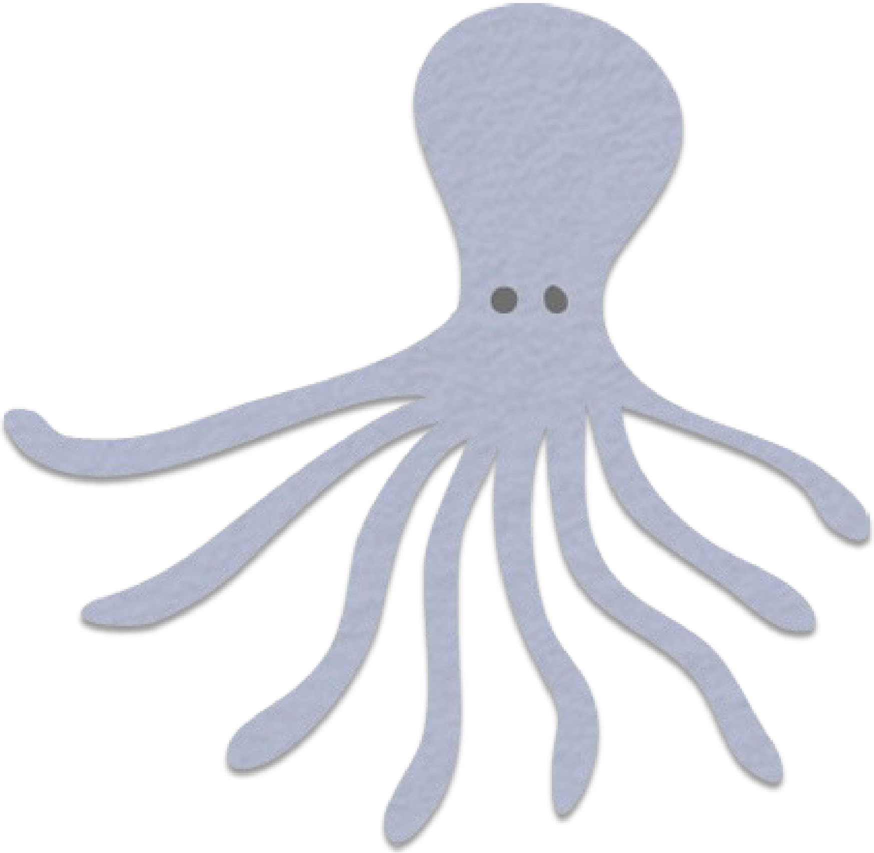
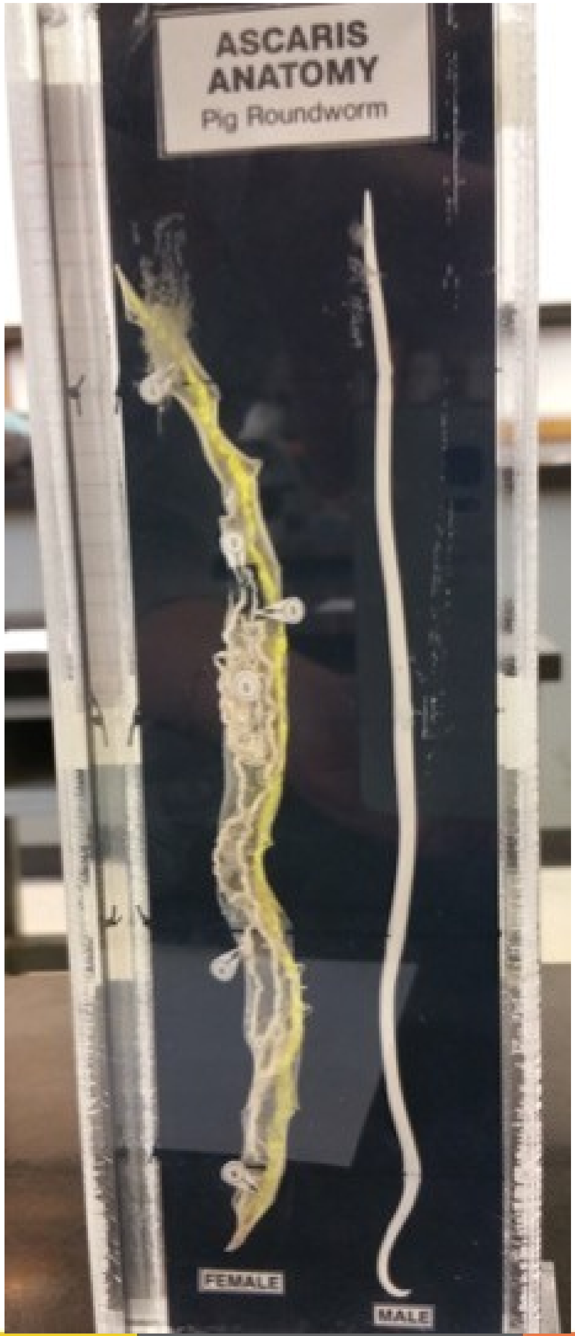
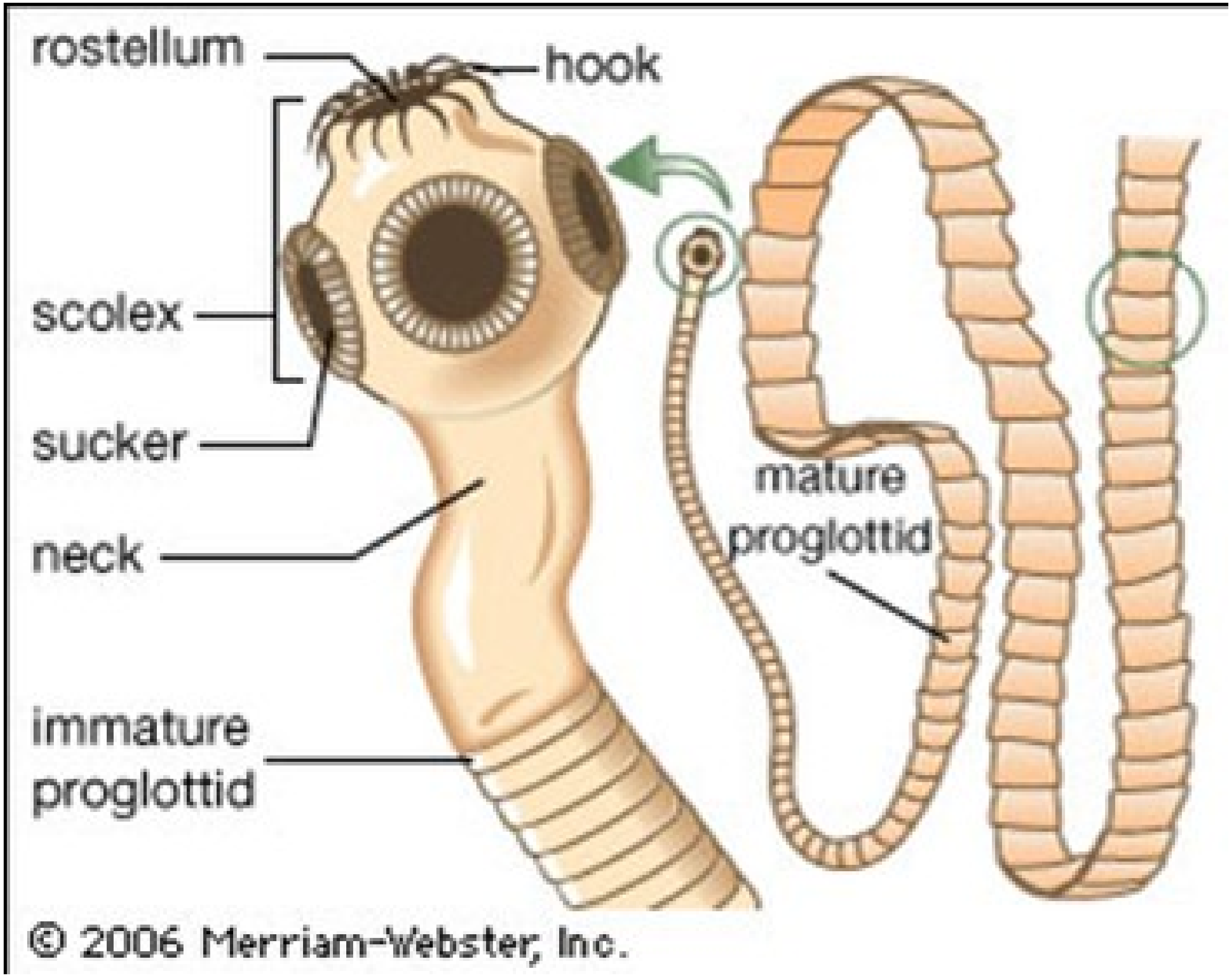





ASCARIS
ANATOMY
Pig Roundworm
FEMALE
MALE



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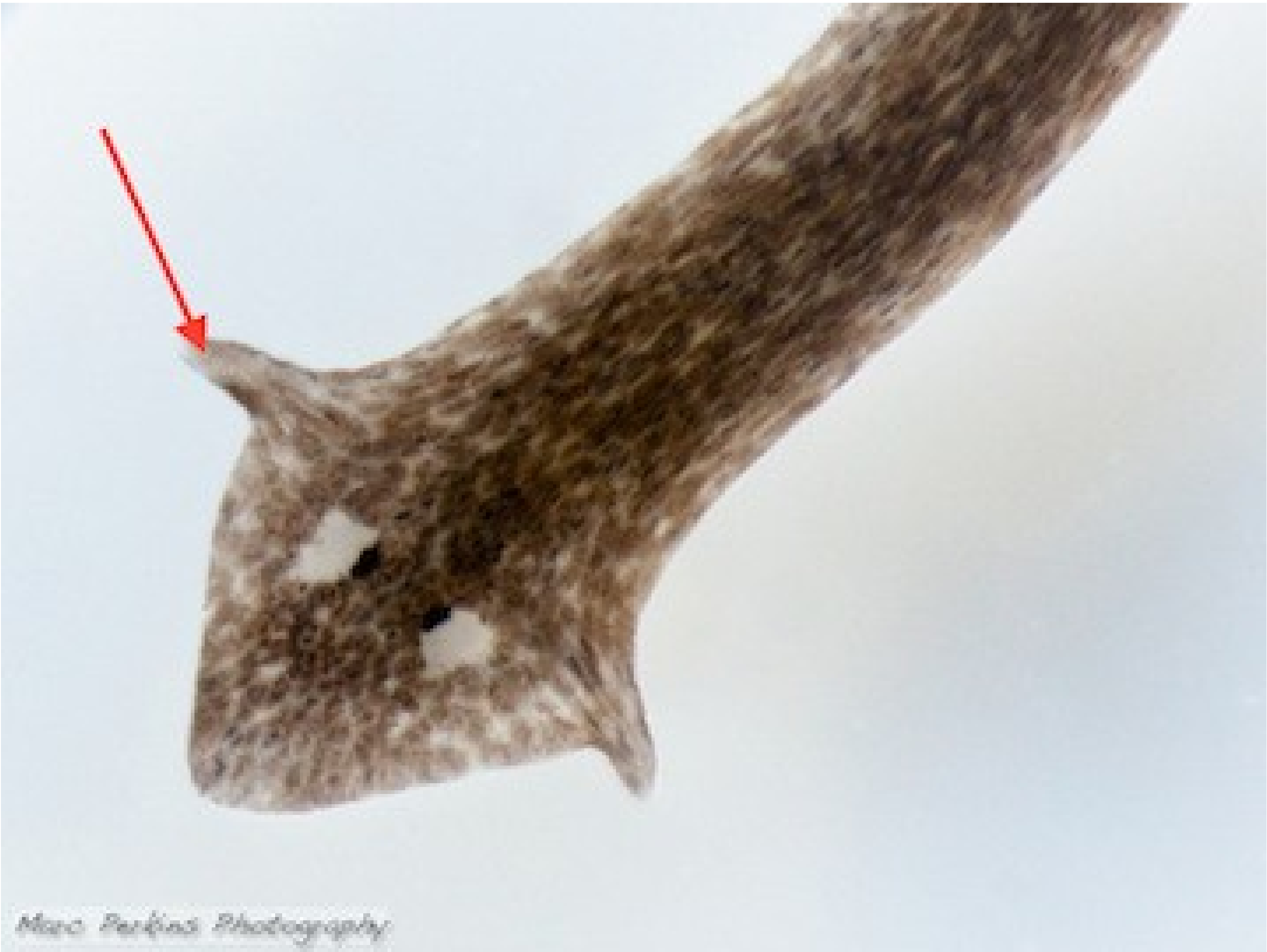
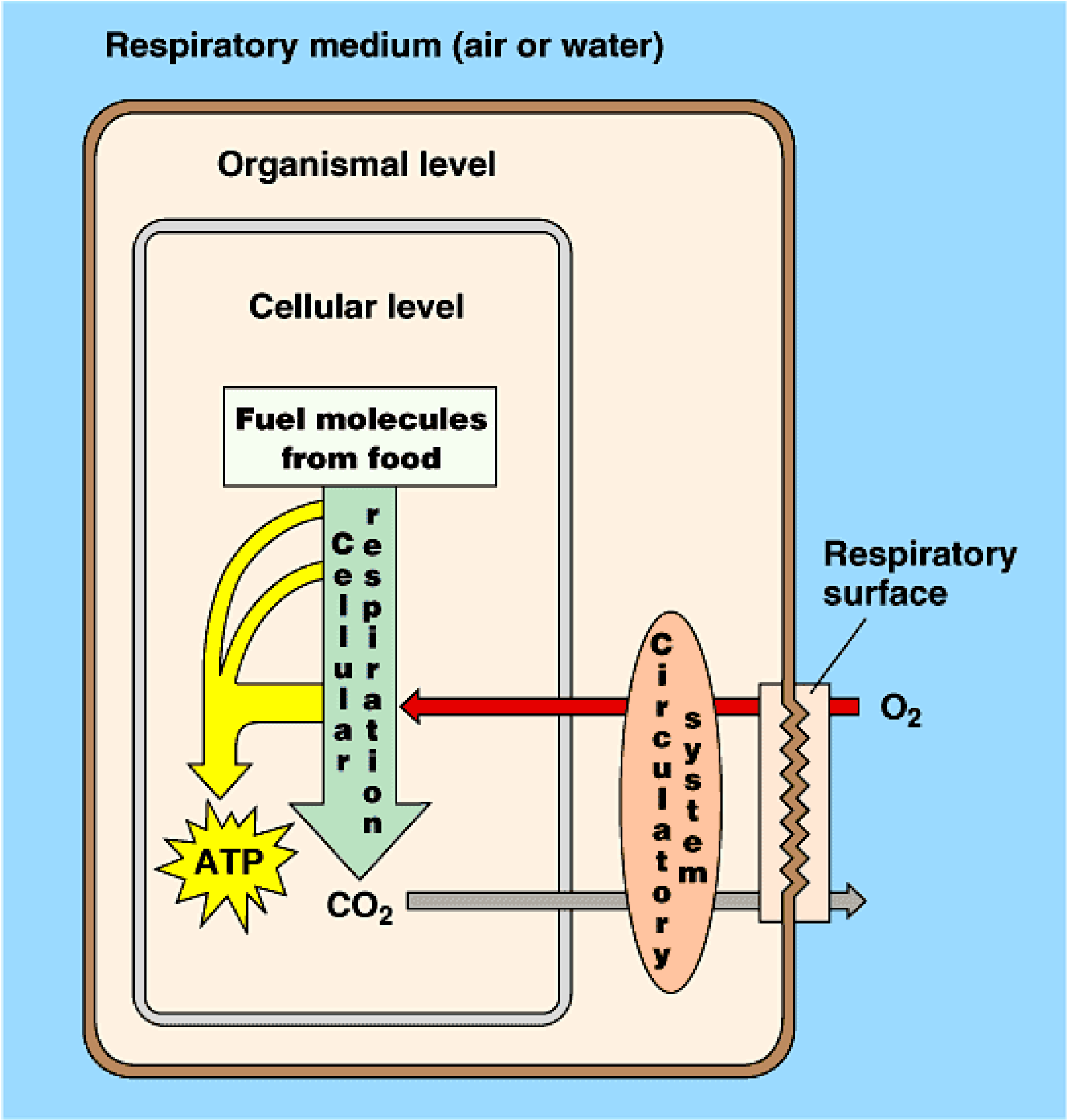

Marc Perkins Photography

Gaseous Exchange Systems Ch42

THE ROLE OF GASEOUS EXCHANGE IN BIOENERGETICS



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Gas exchange 42.5

Moves CO_2 and O_2

- ☐ Between the air and blood
- ☐ Between blood and cells

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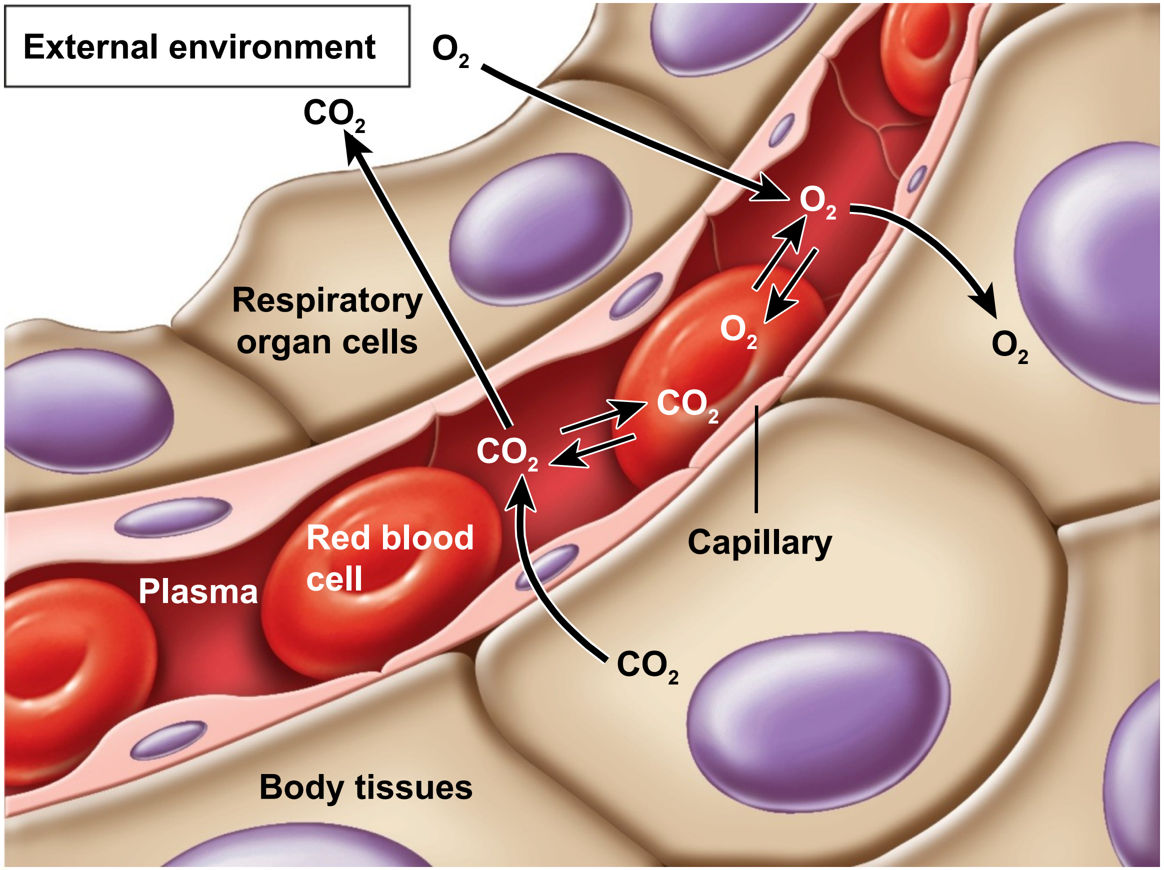


Physical Properties of Gases

Air is

- 21% oxygen (209,445ppm)
- 78% nitrogen
- Less than 1% carbon dioxide and other gases

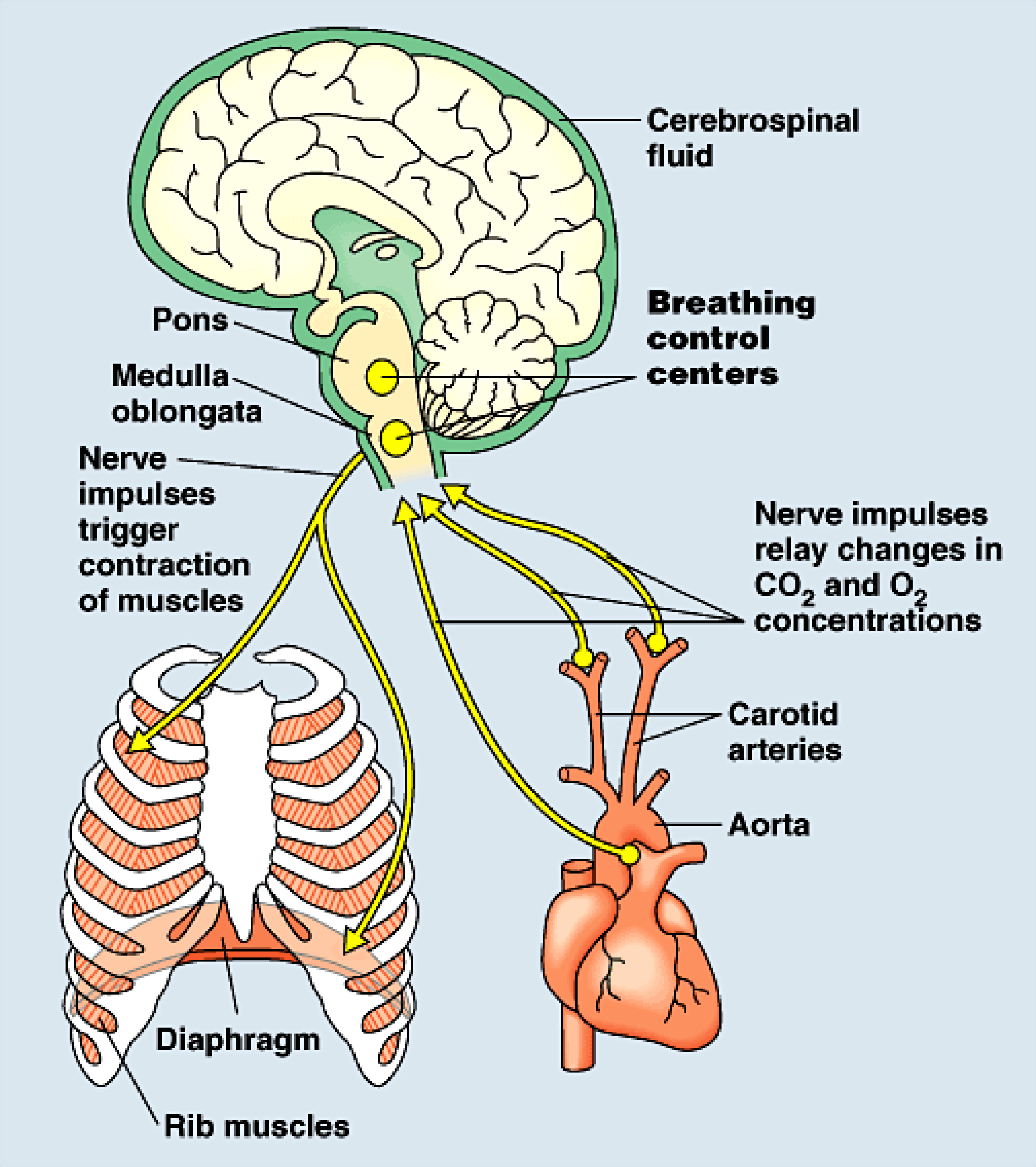
Nitrogen gas usually ignored because it is not part of the respiratory process

Air in seawater can be 0.6% (10-15ppm)

AUTOMATIC CONTROL OF BREATHING 42.6

Respiratory system part 1

Respiratory system part 2



Cerebrospinal fluid
Pons
Breathing control centers
Medulla oblongata
Nerve impulses trigger contraction of muscles
Nerve impulses relay changes in CO_2 and O_2 concentrations
Carotid arteries
Aorta
Diaphragm
Rib muscles

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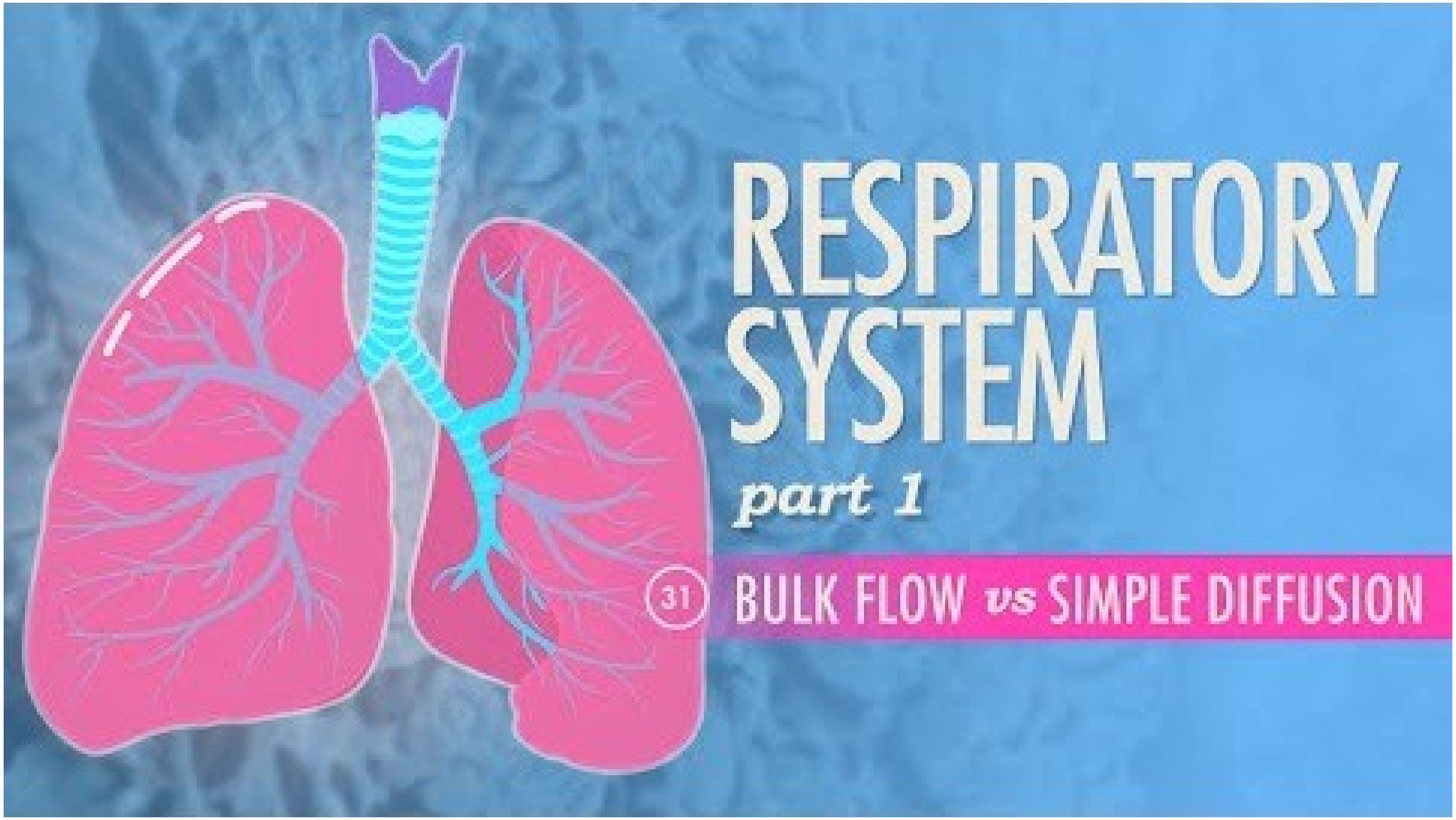
CRASH COURSE RESPIRATORY SYSTEM PART 1


RESPIRATORY SYSTEM
part 1
31
BULK FLOW vs SIMPLE DIFFUSION

0 - 5:36

CRASH COURSE REPIRATORY SYSTEM PART 2 CO_2 HOMEOSTASIS

0 – 1:59, 7:57 - end

EXCRETORY SYSTEMS AND SALT AND WATER BALANCE CH 44

Water is…

- Major portion of an animal’s body mass
- Solvent for chemical reactions
- Transport vehicle

Dehydration compromises the circulatory system and regulation of body temperature

ELECTROLYTES 49.1

Salts dissociate in solution into charged ions

Electrolyte balance is important

Imbalance can alter membrane potential or disrupt cellular activities

NITROGENOUS WASTES (TABLE 49.1)

Product of protein and nucleic acid degradation

Toxic at high concentrations

Three forms

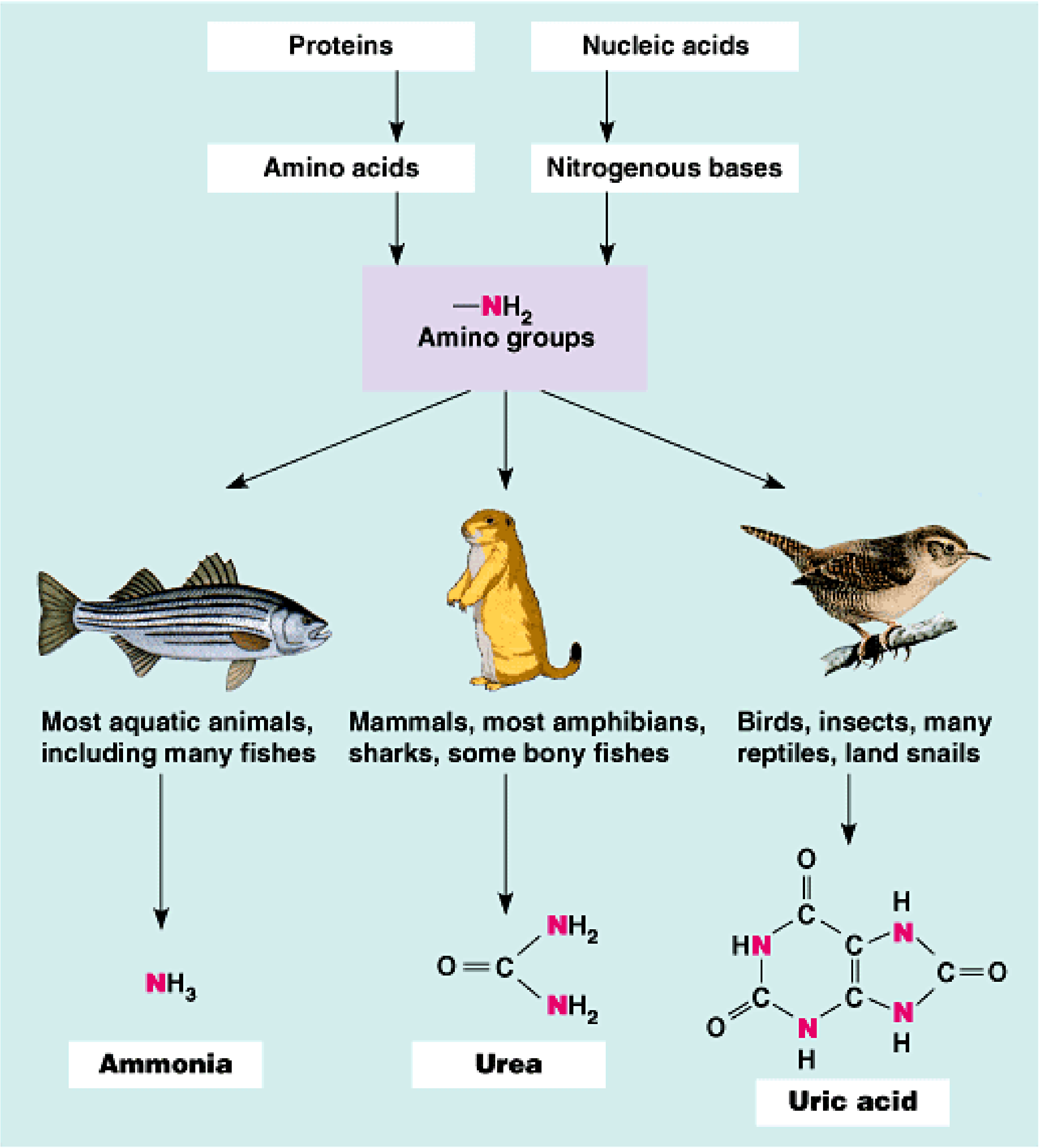
- **Ammonia** and **ammonium ions**
- **Urea**
- **Uric acid**

NITROGENOUS WASTES

Ammonia – less energy to produce but more toxic – need water to dilute it.

Urea – more energy to make it from ammonia (CO_2 + ammonia), but less toxic and also highly soluble in water. Frogs and tadpoles?

Uric acid – non-toxic, doesn't dissolve in water, less water loss, most energy to make it from ammonia.



Proteins
Nucleic acids
Amino acids
Nitrogenous bases
$-NH_2$
Amino groups
Most aquatic animals, including many fishes
Mammals, most amphibians, sharks, some bony fishes
Birds, insects, many reptiles, land snails
NH_3
Ammonia
O=C
NH_2
NH_2
Urea
O
C
HN
C
O
N
H
C
C
H
N
C=O
N
H
Uric acid

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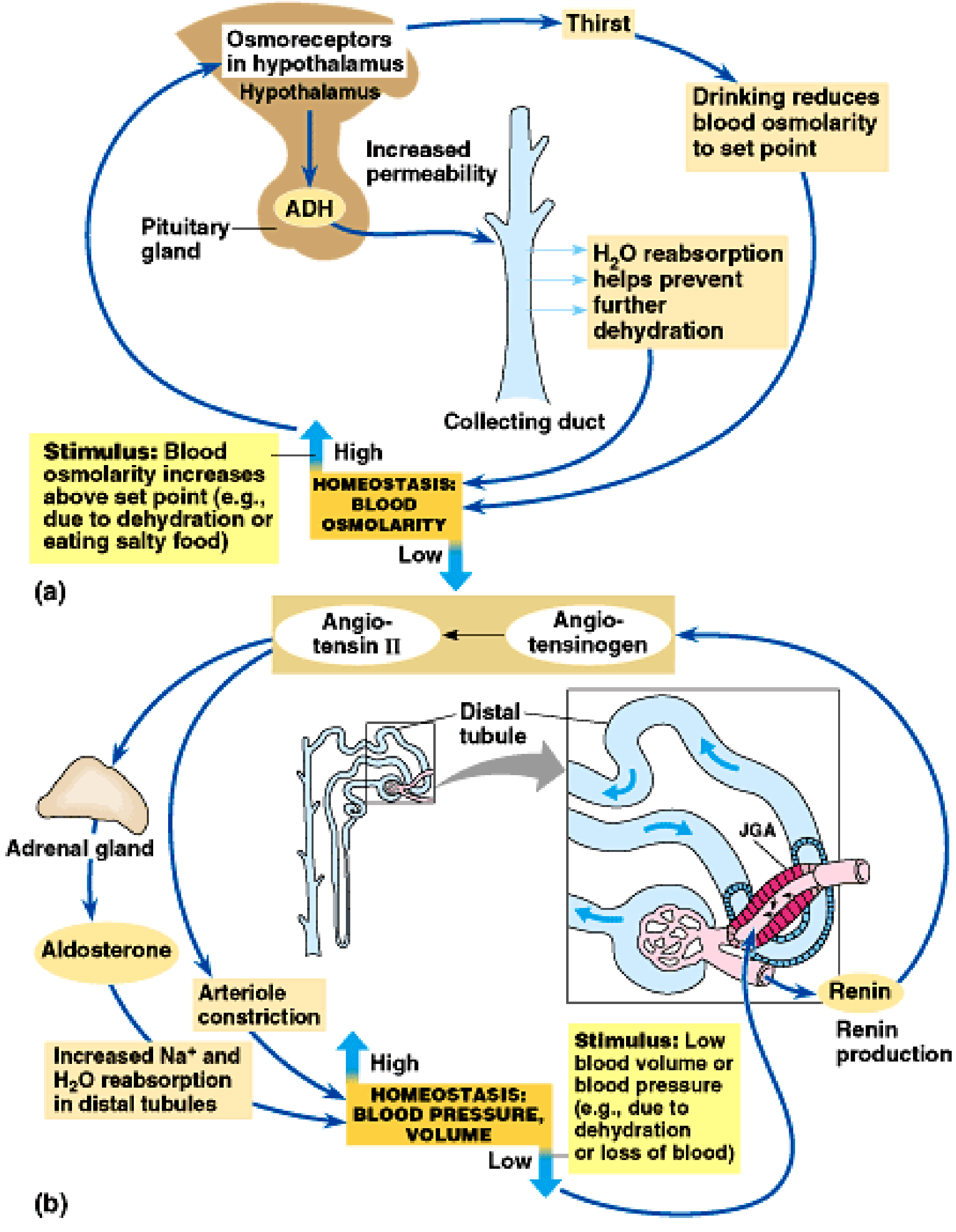
HORMONAL CONTROL OF THE KIDNEY BY NEGATIVE FEEDBACK CIRCUITS

[Kidney function – urinary system]

Thirst controlled by osmoreceptors in hypothalamus when blood is dehydrated or lots of salt is consumed.

Excess water controlled by adrenal gland to increase sodium and water reabsorption in kidney.


Osmoreceptors in hypothalamus
Hypothalamus
Thirst
Drinking reduces blood osmolarity to set point
Increased permeability
ADH
Pituitary gland
H_2O reabsorption helps prevent further dehydration
Collecting duct
Stimulus: Blood osmolarity increases above set point (e.g., due to dehydration or eating salty food)
High
HOMEOSTASIS: BLOOD OSMOLARITY
Low
(a)
Angio-tensin II
Angio-tensinogen
Distal tubule
JGA
Adrenal gland
Aldosterone
Arteriole constriction
Increased Na^+ and H_2O reabsorption in distal tubules
High
HOMEOSTASIS: BLOOD PRESSURE, VOLUME
Low
Stimulus: Low blood volume or blood pressure (e.g., due to dehydration or loss of blood)
Renin
Renin production
(b)

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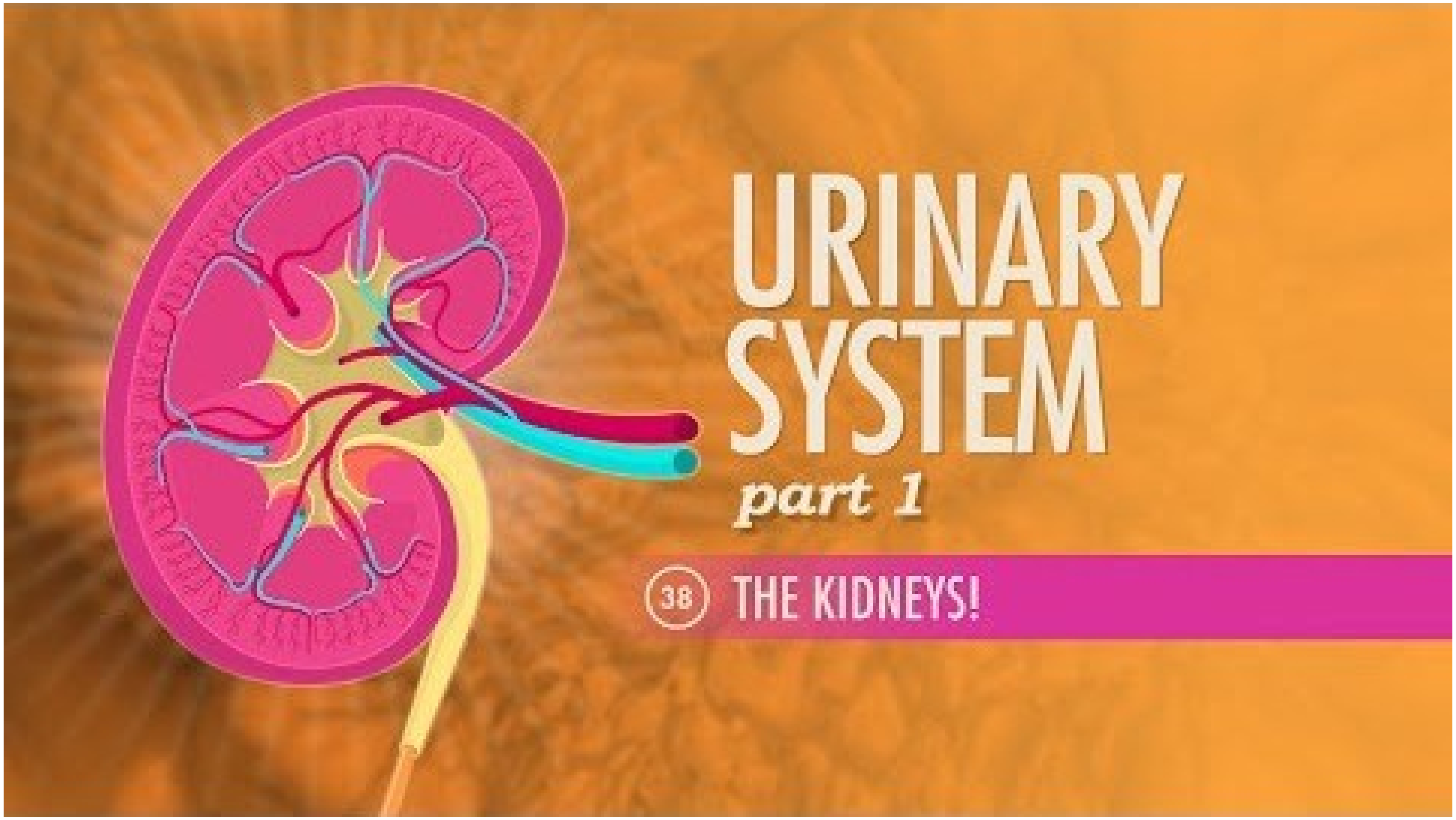
CRASH COURSE URINARY SYSTEM



CRASH COURSE URINARY SYSTEM 2